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Enthusiasm

ENTHUSIASM is the flywheel which takes a man over the dead-center of inertia; it may add little to the turning effort, but its effects are most prominent where otherwise stalemates would occur. In itself it is neither energy nor capacity, but its effect is to stimulate both when events are at the lowest ebb. It should not be confused with tenacity of purpose, but no protracted series of activity is possible without initial enthusiasm.

Its exterior manifestations are a matter of temperament, and to some extent it is regrettable that age has a dampening effect, yet no man worth while is really deficient in this laudable though secondary emotion. Belief in oneself is a species of enthusiasm, the vicious aspect of which, when carried to the fullest extent, becomes self-sufficient egoism—a trait, however, which can only characterize inferior intelligence. Unfortunately, there are many whose mission in life seems to be to damp youthful ardor and discourage enthusiasm.

There is always hope for the man who has enthusiasm; it will carry him over many an obstacle, and while it is no substitute for capacity, it enhances the latter in strict ratio to the mental qualities and adds greatly to intrinsic worth.

Finally, it is a peculiarly optimistic faculty; it says yes rather than no, and for this reason should be stimulated rather than discouraged.

Contributed by A. L. HAAS.

Soot Blowers for Vertical and Hollow Stay-Bolt Boilers

Details of the various systems employed. Protection for blower elements in high-temperature zones. Blowers for hollow-stay-bolt boilers. Special makes of blower and a system designed for continuous soot removal.

IN THE vertical boiler rotating elements are used wherever feasible, their location depending on the boiler design and the arrangement of the baffling. Fig. 1 shows a typical Vulcan installation for a Stirling boiler. The elements serving the second and third banks of tubes are of standard design. In the first pass, where temperatures are high, special precautions are taken to avoid the burning out of nozzles and piping as well as to avoid warping. To clean the lower part of the first bank of tubes where the baffle is located at the rear of the bank, as in Fig. 1, the older method was to rest the cleaner element upon bearing blocks placed on the bridge-wall adjacent to the mud drum, with an extension wall built up in front of the element to protect it from the scrubbing action of the hot gases. This arrangement has been replaced by an element composed of extra-heavy wrought-steel pipe, covered by sectional cast-iron rings with telescopic ends to allow for the expansion and contraction of the metal. The combination is similar to that used in the construction of the Foster superheater, and not only protects the element from the scrubbing action of the hot gases, but prevents warping. This element is placed at the rear of the bank of tubes just over the mud drum, and is further protected by a short baffle placed between the first and second rows of tubes.

For cleaning the upper part of the bank, a similar element is placed above the circulating tubes connecting the first and second drums. This location is out of the hot-gas currents and offers a wide range for cleaning the first and second passes as well as the superheater when there is one installed. Over the top of the element is placed a layer of tile in "tent" form, so as to make a tight joint and at the same time permit rotation.

There are Stirling boilers where the baffle of the first bank is placed between the first and second rows of tubes, as shown in Fig. 2. In this case a standard rotating element is placed at the rear and near the top of the baffle. With a radius of 180 deg. it covers the tubes in the bank in either direction.

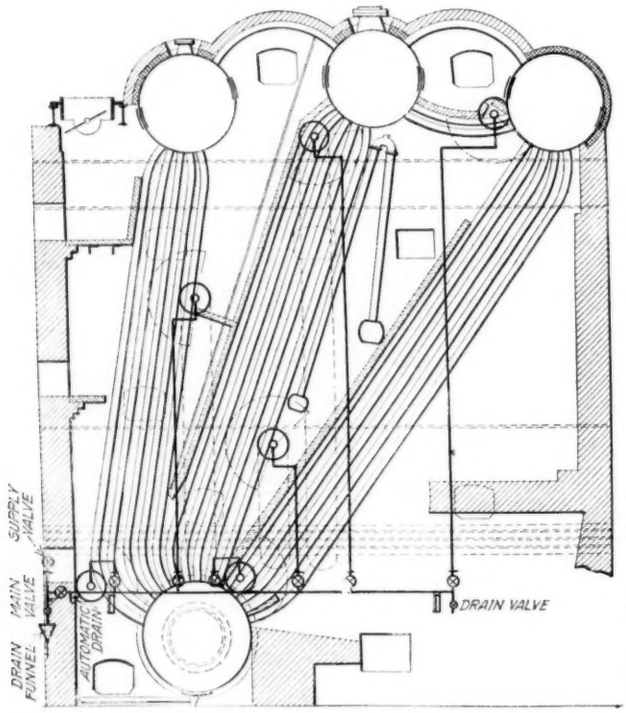


FIG. 1. VULCAN SOOT CLEANER ON STANDARD STIRLING BOILER

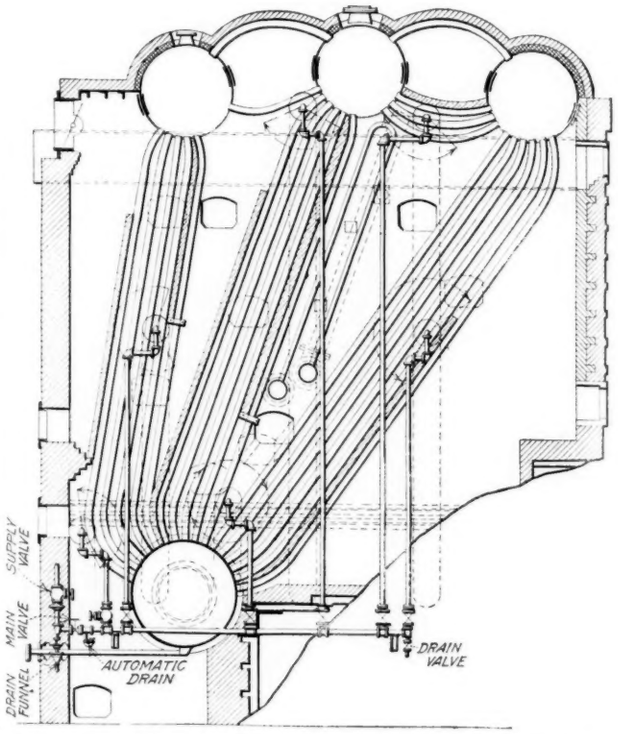


FIG. 2. VULCAN SOOT CLEANER ON SPECIALLY BAFFLED STIRLING BOILER

Fig. 3 shows an installation on a 2365-hp. double Stirling boiler employing both stationary and rotatable elements. At the top of each half of the boiler is a series of two-way nozzles directed downward on the surface of the first pass. There are also revolving elements above the mud drums. Other rotatable elements serve the superheater and the second bank of tubes. The cleaner installation is duplicated on each side and also from each end.

Badenhausen or Connelly boilers offer practically the same problems as the Stirling. The Erie City vertical

and Rust boilers are cleaned up by rotable elements placed to cover the heating surface. In the Wickes type of boiler a modification is required owing to the limited space between adjacent rows of tubes. Rotatable elements are used—one of the standard type, placed above the central baffle where the space between the

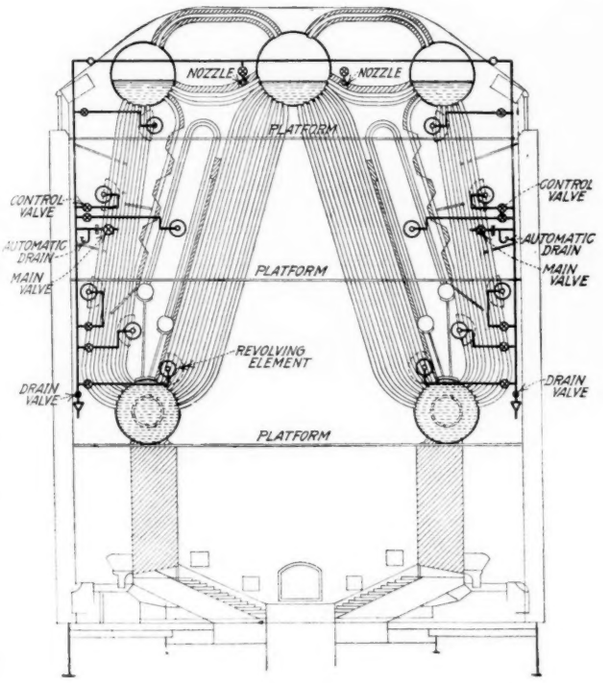


FIG. 3. VULCAN SOOT CLEANER ON 2365-HP. W-TYPE STIRLING BOILER

tubes is wider, and the others of a telescopic design, with nozzles for every other space. When one set of tubes has been cleaned, the telescopic elements are shifted longitudinally so that the jets register with the alternate spaces. The location of the elements is shown in Fig. 4, and Fig. 5 shows how the telescopic element is shifted in and out. With this design the instantaneous demand for steam is less as the nozzles are reduced by half, so that a smaller pipe that will fit the space between the tubes may be used.

In Diamond installations for vertical water-tube boilers, with one or two exceptions, standard units may be applied. They are arranged to cover the surface and the use of "insuluminum" units in high-temperature zones, such as the first pass of the Badenhausen, Connelly, Stirling and similar boilers, lessens the need for protective baffling or locations out of the direct current of the hot gases. The standard six-unit Stirling installation shown in Fig. 6 will give an idea of the general plan followed. It will be noticed that the vertical header is retained and that the various units are placed to best cover the heating surface. Fig. 7 shows a blower system on a 2365-hp. double Stirling boiler. Sixteen elements on each end, or a total of 32 per boiler, are employed. In Fig. 8 is shown the system used on the 2400-hp. Badenhausen boilers of the Ford plant. Six units on each end serve the front part of the boiler. The rear bank of tubes and the economizer, which is integral with the boiler, are cleaned by four blowing units inserted through the back wall of the boiler at right angles to the other units. These four elements clean 800 tubes without necessity for working radius greater than five feet for any one unit.

Cahall boilers are cleaned by a centrally placed vertical unit such as is shown in Fig. 9. The blower element rests in a bearing on top of the lower drum and is supported at intervals in the height. The method of rotation and the means of admitting steam are indicated in the drawing.

In the Wickes boiler standard units are used where the spacing between the tubes will permit. Tubes over the arch are cleaned by a special removable unit of small diameter with a venturi nozzle for each row of tubes. As shown in Fig. 10, the unit is permanently secured to the boiler shell and a steam-tight universal

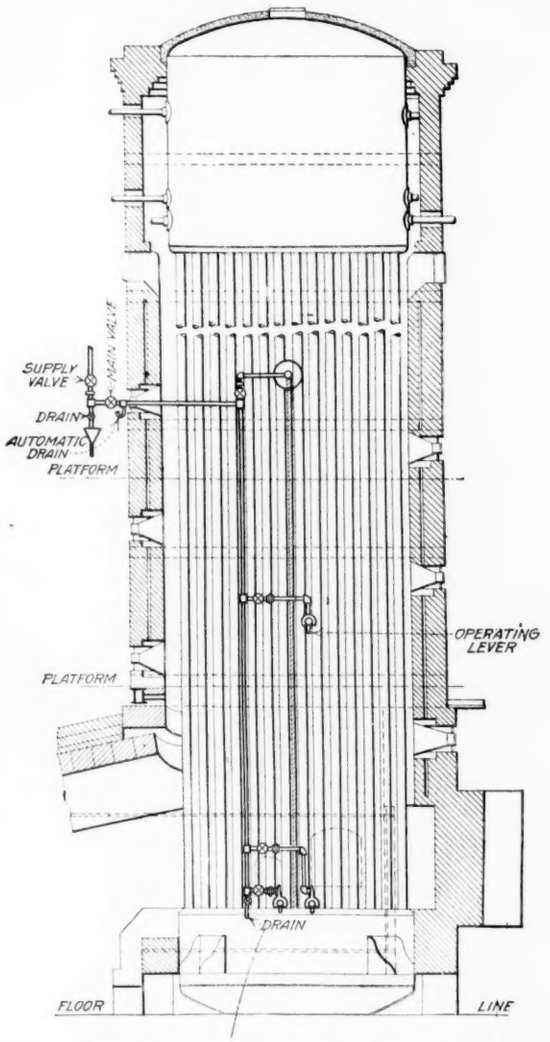


FIG. 4. VULCAN SYSTEM OF CLEANING WICKES BOILER

joint permits ready removal of the element from the tube space when it is not in operation.

For horizontal water-tube boilers with hollow stays and horizontal baffles, such as the Heine, Keeler, Casey-Hedges, Edge Moor, Geary and a number of others, the Diamond Power Specialty Co. makes the soot-blower system shown in Figs. 11 and 12. In general, it consists of two main pipes from which extend branch pipes to every hollow stay. Being arranged to clear the hand-

hole yokes, the blower is permanently installed on the front water-leg of the boiler. It is operated from the front by means of two valves. The nozzles are of venturi type, and over the baffles where soot deposits may be heavy they extend into the setting from two to eight feet. The system blows against the draft

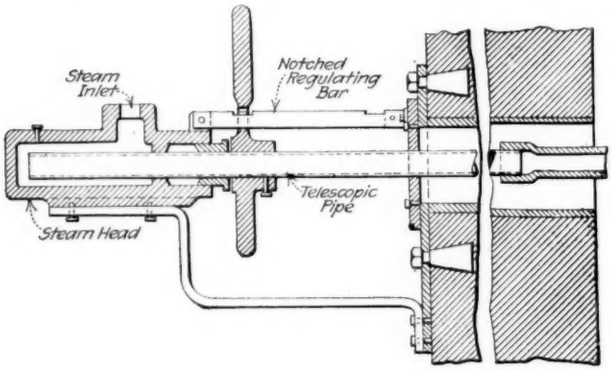


FIG. 5. DETAIL SHOWING HOW TELESCOPIC ELEMENT FOR WICKES BOILER IS SHIFTED

and cleans half the tubes, laterally, at a time. Whenever necessary, one or more rotatable elements are employed in addition to the hollow stay-bolt blower.

Fig. 13 shows the soot blower made by the Bayer Steam Soot Blower Co. for horizontally baffled hollow-stay-bolt boilers. Steam from the main supply flows

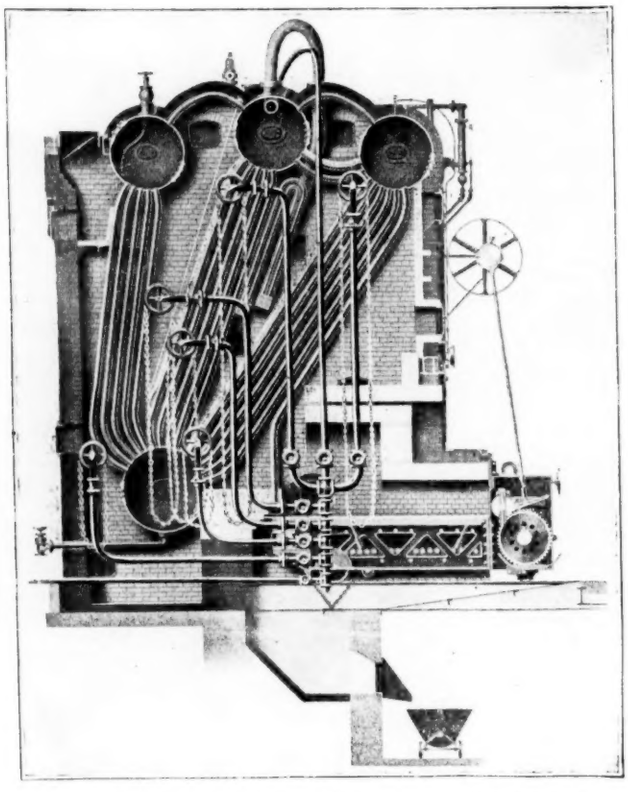


FIG. 6. STANDARD DIAMOND SIX-UNIT STIRLING INSTALLATION

to the nozzles through horizontal cross-headers at each end of the boiler. These headers are each controlled individually by a stop valve, so that when desirable one set of nozzles may be operated at a time. In normal operation the main supply valve is first opened, then the drips to free the system of accumulated water, and finally the header valves are opened in pairs or individually, depending on conditions and the manner in which the boiler is baffled. This system is applied to boilers having three horizontal baffles as well as to those having the usual construction of two horizontal baffles.

A detail view of the headers and nozzles, Fig. 14, shows the methods of support, the nozzle design and the general arrangement. It will be seen that the nozzles extend through the hollow stays and slightly beyond the inner face of the water-leg, excepting certain nozzles on the lower front unit. The complete system ordinarily consists of one or two main units applied to the rear water-leg, according to the number

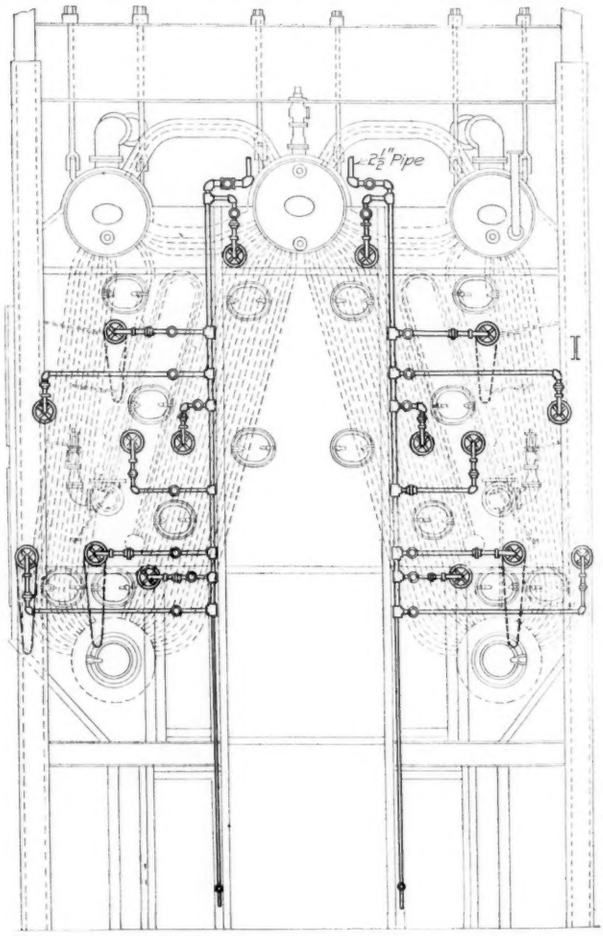


FIG. 7. DIAMOND BLOWER ON 2365-HP. DOUBLE STIRLING BOILER

of rows of tubes in the boiler vertically, and three auxiliary single units. The illustration, Fig. 13, shows one main unit and one auxiliary unit on the rear water-leg and two auxiliary units on the front water-leg. The main unit as applied to the rear water-leg performs most of the service of cleaning the boiler tubes, blowing in the direction of the draft. The three auxiliary units are used to remove accumulations of soot from the baffles. The lower front unit is constructed differently from the other two auxiliary units in that it is provided with alternately long and short nozzles. The long nozzles extend six to eight feet inside of the front water-leg, just above the lower baffle, their function being to remove the soot tending to accumulate on the

extreme end of this baffle. The shorter nozzles remove the soot accumulating at the corner formed by the lower baffle and the front water-leg. The auxiliary unit on the rear water-leg performs this same service in connection with the accumulation of soot in the corner formed by the upper baffle and the rear water-leg. The auxiliary unit on the upper part of the front water-leg is intended to clean the forward part of the upper baffle. Fig. 15 shows the main zones of soot deposit in this type of boiler and makes evident the need for the auxiliary units. The nozzles used in this system are all of the straight-bore type.

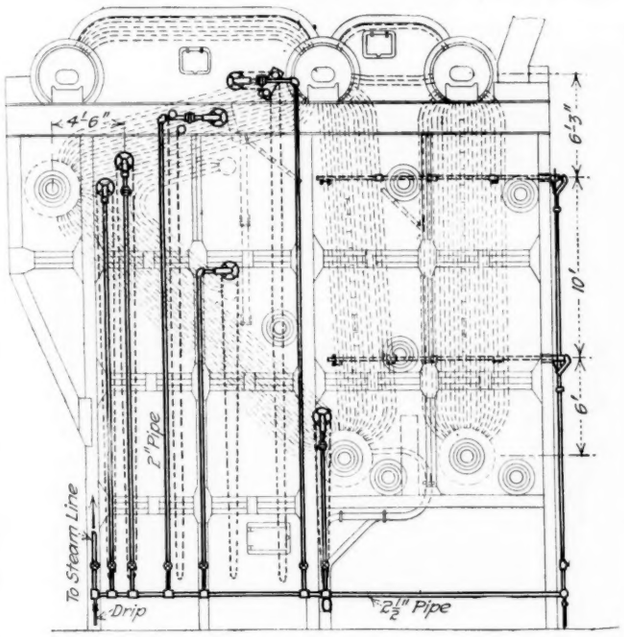


FIG. 8. DIAMOND BLOWER SYSTEM ON 2400-HP. BADENHAUSEN BOILER AT FORD PLANT

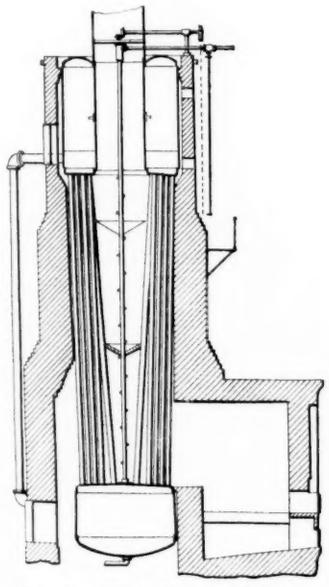


FIG. 9. DIAMOND VERTICAL UNIT FOR CAHALL BOILER

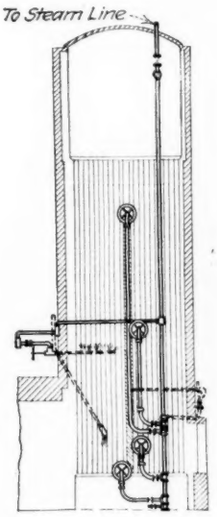


FIG. 10. WICKES BOILER SERVED BY DIAMOND BLOWER

The Bayer soot blower for Stirling and vertical boilers presents several novel features. An installation for a small Stirling boiler is shown in Fig. 16. The number of units is varied according to the size of the boiler. This system is a combination of the usual revolving element and two other specially designed elements known respectively as the heatproof, tile-jacketed, air-vented unit and the geared rotating-arm unit. A sectional view of the tile-covered element is shown in Fig. 17. This unit consists of the ordinary rotating element operated by sprocket and chain, but with that part which extends across the boiler chamber covered with cylindrical tile made in removable sections and with an air space between the tile covering and the body of the unit which carries the steam. Air is bypassed to this space at the wall end of the unit by a small pipe placed within the pipe of the blowing element, and circulation of this air is promoted by air ports through the cylindrical tile at the opposite end of the unit. That portion of the tile bearing on the inner pipe is constructed to permit free passage of the air. The tile cylinders are cast with tapering holes for the insertion of the steam nozzles. After the latter have been placed, the openings around them are closed with fireclay.

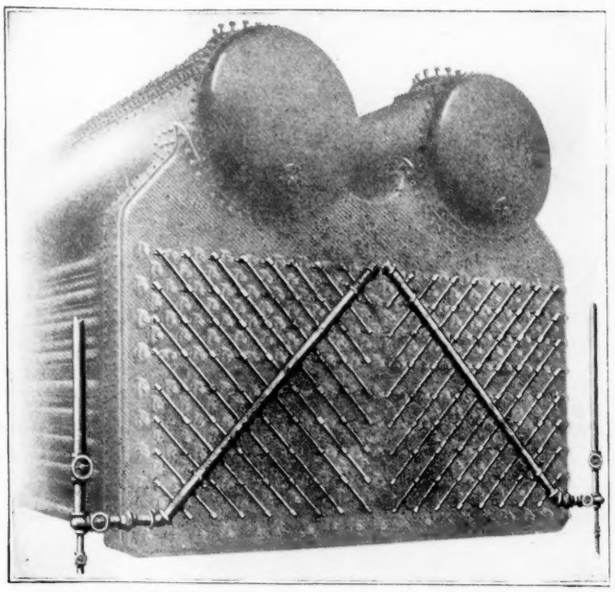


FIG. 11. STANDARD DIAMOND HOLLOW STAY-BOLT INSTALLATION

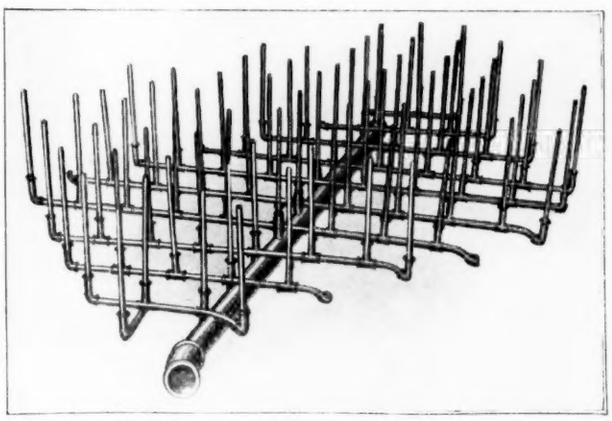


FIG. 12. ASSEMBLED DIAMOND SOOT BLOWER FOR HOLLOW STAY-BOLT BOILERS

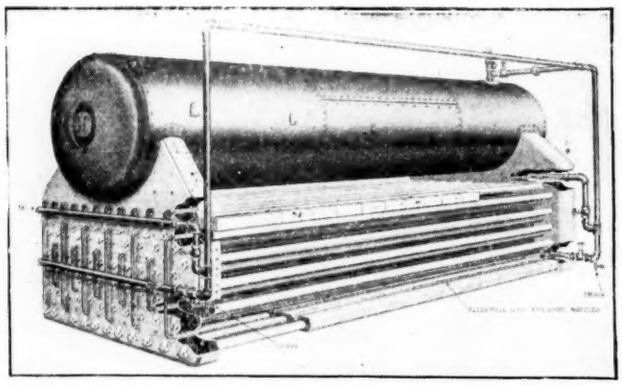


FIG. 13. BAYER SOOT BLOWER FOR HOLLOW STAY-BOLT WATER-TUBE BOILERS

The tile-jacketed element is used in the high-temperature zones of the boiler. It is placed above the circulating tubes between the first and second drums and especially at the bottom of the first bank of tubes, in the form of either a revolving or a stationary unit. When used as a stationary unit, the element in addition to the tile covering is embedded in the bridge-wall and the whole is then covered with fireclay. The nozzles in this case are made longer to provide for the thickness of the additional covering of fireclay.

Fig. 18 shows the Bayer geared rotating-arm unit. One of the advantages claimed for this construction is that it provides for cleaning a certain portion of the tubes of the second pass while the principal working

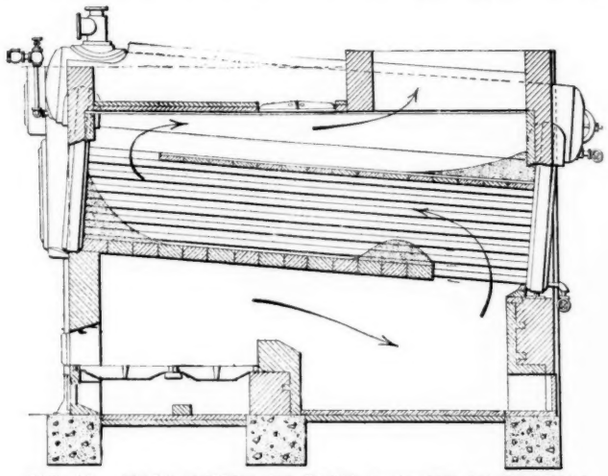


FIG. 15. MAIN ZONES OF SOOT DEPOSIT IN TYPICAL HOLLOW STAY-BOLT BOILER

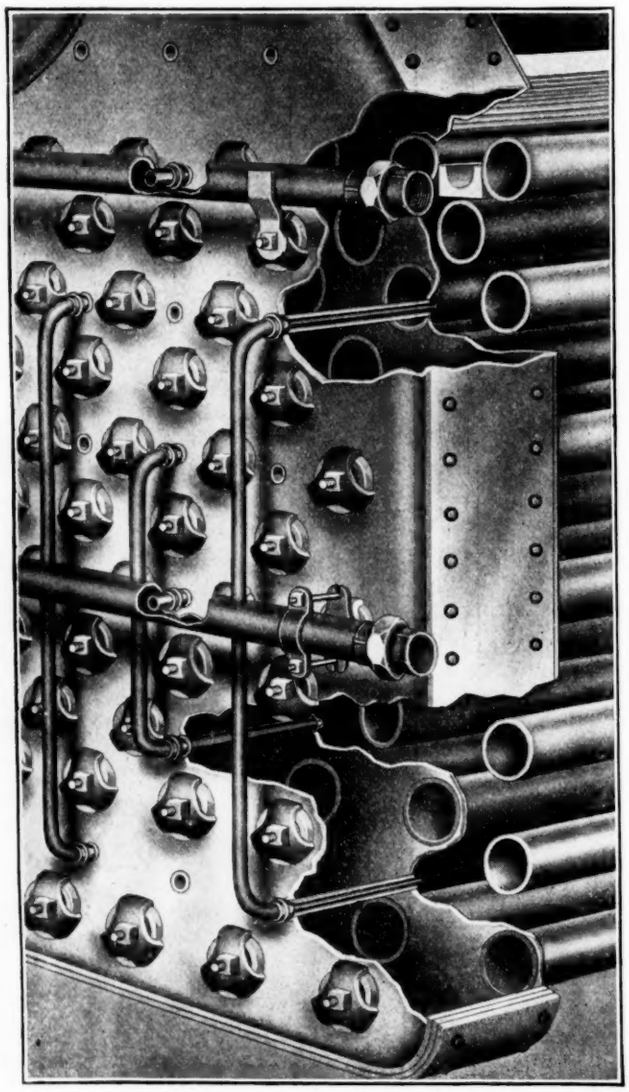


FIG. 14. CONSTRUCTION OF BAYER HOLLOW STAY-BOLT BLOWER

parts are in the third pass, where the temperature is lower. Cleaning is accomplished by four steam jets issuing from a revolving arm placed near the center of the bank of tubes and at right angles to the plane of the tubes, so that the steam jets will have a clean passage between the rows. The element is controlled and operated from the floor by the usual sprocket-and-chain method, the sprocket wheel being connected to a shaft extending through the stationary steam-

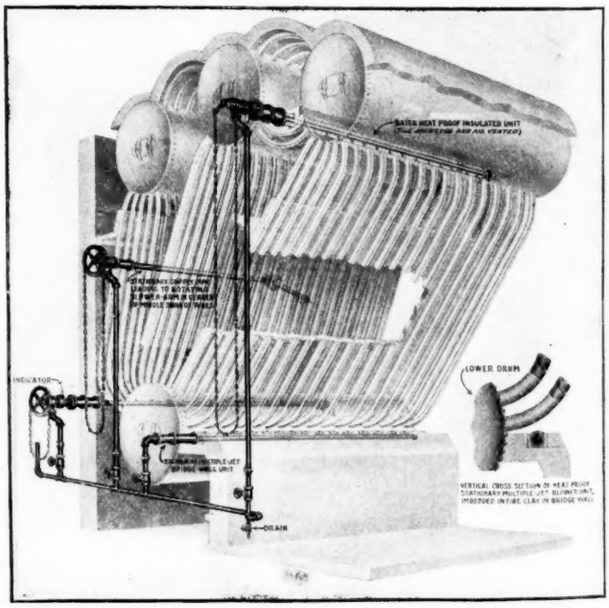


FIG. 16. BAYER COMBINATION SYSTEM FOR SMALL STIRLING BOILER

supply pipe. A universal joint connects this shaft to the worm gear rotating the blower arm. The worm gear is protected by a cast-iron housing with a packed gland so that neither soot nor grit can enter. A flanged union connects the rotating arm to the gear shaft, so that the arm may be removed without disturbing the

other parts of the element. The unit is supported by the wall bearing and by clamps that extend through the baffle and are attached to the nearest tubes.

The Burton soot blower, made up specially by the Page Boiler Co. for use on its sectional water-tube

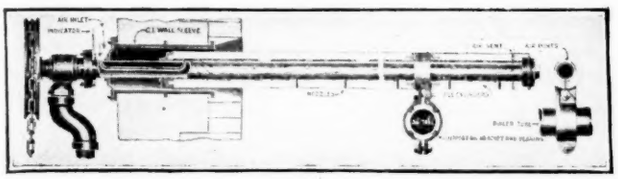


FIG. 17. BAYER TILE-JACKETED AIR-VENTED UNIT FOR STIRLING AND VERTICAL BOILERS

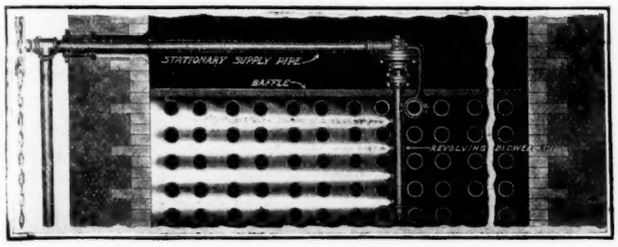


FIG. 18. BAYER GEARED ROTATING ARM UNIT FOR STIRLING AND VERTICAL BOILERS

boiler, is shown in Figs. 19 and 20. With the inclined arrangement of the sections and only one pass for the gases, a single soot-blowing element covers the entire surface. It extends across the setting immediately below the drum at the apex formed by the crossing of

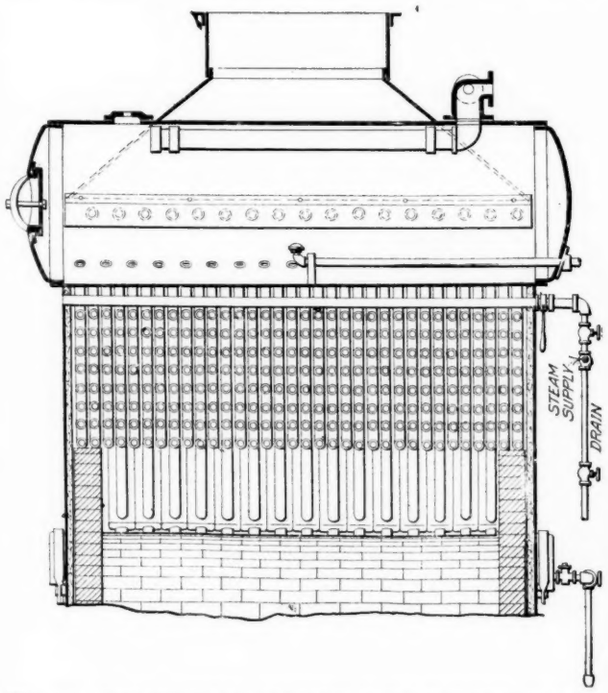


FIG. 19. TRANSVERSE SECTION PAGE-BURTON BOILER, SHOWING BURTON OSCILLATING SOOT BLOWER

the sections, when the gas temperature does not exceed 700 deg. The blower is equipped with a parallel-bore nozzle for every space between the tubes. It is revolved through an arc of 240 deg. by a handle outside the setting, steam being admitted from the supply pipe through a swing joint. The handle is in line with the nozzles so that their position is always indicated. Boilers up to one thousand horsepower are served by the one element. Owing to the inclined arrangement of the sections the depth of the boiler is comparatively short, and as the element is located at the center, the range through which the steam jets act is not excessive.

Another blower made specifically for the boiler it is to serve is the Edge Moor intra-baffle soot blower. It is of stationary design and is placed within the cross-baffles separating the gas passages. The nozzles project through the baffles and in each pass blow toward the front of the boiler parallel to the tubes. The cross-baffles of the boiler are made up of sectional cast-iron plates, bolted together at the ends to make a continuous wall, which is covered on both sides by hot-blast cement. To accommodate the nozzles, slotted holes are cored in the iron plates between the semicircular slots provided for

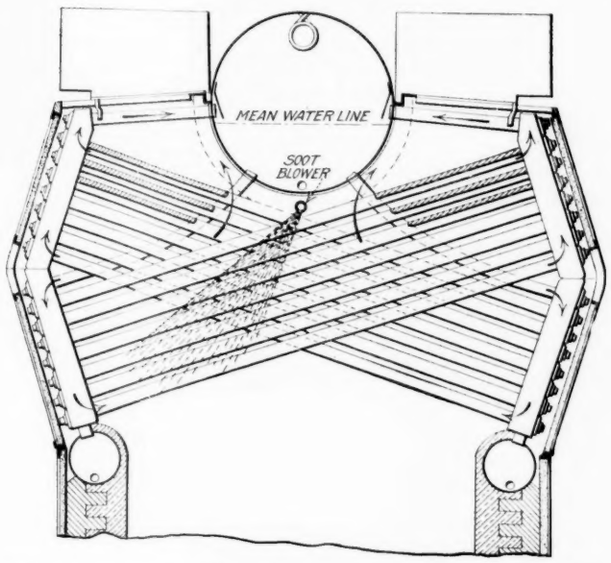


FIG. 20. LONGITUDINAL SECTION OF BOILER, SHOWING LOCATION OF BLOWING ELEMENT

the tubes. The asbestos cement protects the nozzles and the nozzle pipes as well as the baffle plates.

Fig. 21 shows the general arrangement. A horizontal header passes across the setting at right angles to the tubes. From the header a series of pipes lead up diagonally among the tubes. Each pipe carries a number of nozzles. The nozzles blowing the first pass extend through the iron baffle plate and firebrick tile which protect them from the heat. In the other passes the nozzles and nozzle tubes are protected by hot-blast cement. In the last pass the nozzle pipes are placed against the rear header and are covered with the cement. Quick-opening valves admit steam to each header and a special bypass is provided for warming the piping and clearing it of water before placing the blowers in operation. A drain with a hand-operated valve is provided for each horizontal header.

Before closing the subject of soot removal from water-tube boilers, mention should be made of a device designed by C. M. Garland, of Chicago, to make the cleaning process continuous. It is generally recognized that the shorter the interval between the time of the deposit upon the surfaces and the time of the removal the easier the cleaning is affected, and from the view-

point of thermal conductivity the shorter the time the soot remains upon the surface the higher the efficiency of the boiler. Consequently, the blower operated most frequently without introducing impractical complications, should have the advantage. The continuous process is carried out by the insertion of automatically operated quick-opening valves in each unit of any of the well-known soot-blowing systems. It is preferably used on systems having stationary nozzles blowing

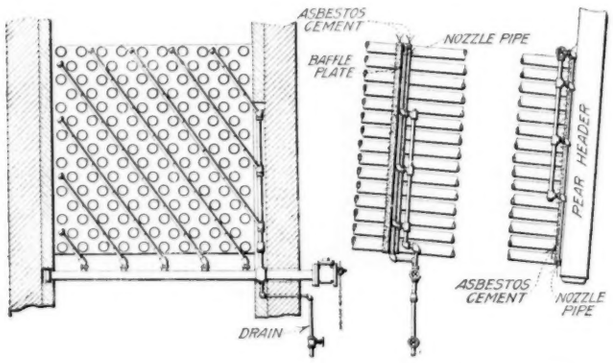


FIG. 21. EDGE MOOR INTRA-BAFFLE SOOT BLOWER

parallel to the surface to be cleaned, but at a considerably increased initial cost can be applied to systems having rotatable elements.

The valves may be of the solenoid-operated type controlled by a contact device similar to an electric sign flasher, or they may be mechanically operated by reach rods and a motor-driven camshaft. Instead of being operated two or three times a day for intervals of five or six minutes, the valves are designed to operate for a short period of time at regular intervals of several minutes. A valve operated for one second every five minutes in the day would open 288 times during the 24 hours, and the total period of blowing would aggregate 4.8 minutes. Blowing by hand manipulation would require more time. It is also possible to follow common practice in operating the valves consecutively in the direction of the draft. Full details of this device are published in the June 26, 1917, issue of *Power*.

Hand Control for Forced-Draft Blowers

BY L. B. CASE

Many operators of small boiler plants which use the low grades of anthracite with forced draft and turbo (fan) or steam-jet blowers, do not attempt to control the speed of the blowers according to the thickness of the fuel bed. This means the waste of many tons of coal that could be saved by installing a few simple devices and the use of a little common sense. The accompanying sketch shows one such device that is inexpensive to install and easy for a fireman to understand and operate.

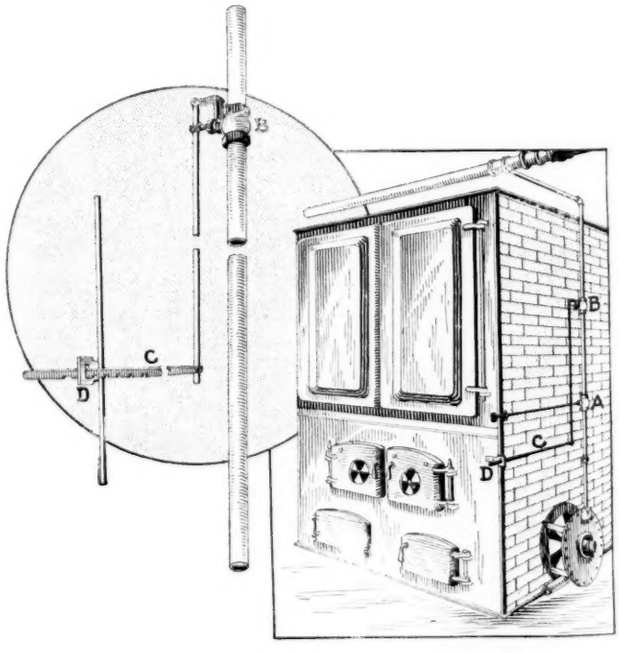
The blower is piped up in the usual manner with a hand shutoff valve *A*, but between this valve and the steam main (or blower regulator if one is installed) is placed a balanced valve, or quick-opening gate valve *B* to act as a throttle valve. The operating lever furnished with the valve should be replaced with one about four feet long to make sensitive adjustments. This lever should be operated from the front of the boiler by the connection *C* passing through bracket *D*, which should not be over $\frac{3}{16}$ in. thick at the slotted or outer end.

With a gas-analysis outfit and valves *A* and *B* wide open, determine the maximum thickness of fuel bed the blower is capable of furnishing air for and maintain proper combustion. Note this height on one of the fire-doors, also cut a notch in connection *C* at the bracket *D* about $\frac{1}{4}$ in. wide. This allows the connection to drop a little at this end and prevents it from moving in or out.

Then clean the fire and adjust the speed of the blower by moving connection *C* and closing valve *B* until the flue-gas analysis indicates the flue gases are as desired, after which note the height of the fuel bed on the same boiler door, also cut another notch in connection *C*. Take the fire-door off and tap about $\frac{1}{4}$-in. holes for button-head screws at the places marked, also tap as many holes as desired between these two as located; $1\frac{1}{2}$ in. apart is close enough for practical purposes with such air regulation.

After the door is replaced, a test should be run for each additional screw head placed on the door between the top and bottom ones and a notch cut in connection *C* to correspond to each screw.

It is a simple matter for any fireman to judge the thickness of his fire by the screws in the firing door and



HOW STEAM TO THE FAN IS CONTROLLED

pulling the connection out a corresponding number of notches.

Of course this will not give good results with a blower regulator that opens only in proportion to the load on the boilers, but most of them open wide and allow the blowers maximum pressure, and shut off entirely when the steam pressure has reached the desired point.

If at any time the quality of fuel changes, it is a simple matter to replace the old connection *C* for a new one and graduate it by the same methods.

Lubrication of Air-Compressor Cylinders

By W. H. CALLAN*

Résumé of experience with air-compressor cylinder lubrication, showing that the temperature of the cylinder wall is not much above that of the jacket water, so that a light mineral oil, and little of it, is the lubricant to use rather than oils of heavy grade and high flash point.

A NUMBER of years ago, when our company was young in the compressor business, considerable trouble was experienced in producing a suitable oil for lubricating the air cylinders of the compressors. An expert from a well-known oil company, who had been called in, reported that the trouble was entirely due to using an oil of too light body and too low viscosity to withstand the high heat of the compression. He stated that the oil being used was gasified, owing to the high temperature of the air, and that it passed off in vapor, leaving the cylinder wall without lubrication. The expert thereupon recommended an oil that he considered suitable for our use. The particular grade happened to be of 26 Baumé gravity, with a flash point of 515 deg. F., fire test of 555 deg. F. and a viscosity of 130 S. (Saybolt) at 212 deg. F.

New Oil Does Not Improve Operation

Use of this oil for several days did not improve the operation of the machine. In fact, it appeared to be laboring and the temperature of the discharge air was high. The cylinder heads were removed, the valves taken out and a careful examination made. The cylinder wall seemed to have a sticky, plastic coating; the air passages and discharge cavity of the cylinder showed signs of dark deposits, and the valve seats were covered with a black, hard coating. This hard formation on one side of the valve seat caused the valves to leak, hence the increased temperature of the discharge air. The sticky coating on the wall of the cylinder was responsible for the increased friction. The representative's attention was called to this condition, and he suggested that a little higher gravity oil be used, and this time he recommended one with 27½ Baumé gravity, flash point 450 deg. F., burning point 500 deg. F., and a viscosity of about 125 S. at 212 deg. F. Upon being asked if this oil was not too heavy for air-cylinder lubrication, he assured us it was not and stated that to withstand the high temperature of the compressed air it was necessary to have a rather low-gravity and high-viscosity oil, with a flash point above the temperature of the air.

After this grade of oil had been used for some weeks, a further examination was made; and while the cylinder wall appeared considerably better, the valve passages and discharge cavities of the cylinder were badly coated with a hard deposit. When this matter was again brought to the attention of the expert, he suggested that the amount fed into the cylinder be reduced. This was done with great care until only three drops a minute were being fed into a 14 x 14-in. cylinder, running at 150 r.p.m., but even then the deposits in the valve passages and the discharge cavities of the cylinder continued to form as long as this oil was used.

After several month's operation the formation in the discharge passages had collected to such an extent that it was necessary to clean the passages to avoid the hazard of an explosion. An analysis of some of the material removed showed 1.5 per cent. free oil, 11 per cent. rust, 5 per cent. decomposed oil, 30 per cent. mineral ash, 10 per cent. coal dust and the remainder foreign matter or residuum. A further investigation showed that the air intake was exposed to such material as coal dust, mineral ash, shavings and water.

After cleaning the compressor and safeguarding the intake against dirt and dust, a lighter grade of oil of 31 Baumé gravity, flash point 375 deg. F., burning point 420 deg. F., and with a viscosity of 200 S. at 100 deg. F., was procured. At first it was fed at the rate of three drops a minute, but upon finding the cylinder copiously oiled, the rate was reduced to two drops a minute. Lubrication with this oil was continued for a considerable length of time with practically no trouble from carbon deposits.

Experiencing such good results from this light oil and by this time disbelieving the virtues claimed for low gravity, high flash point and heavy viscosity, we were prompted to try another grade of oil, selecting one having a gravity of 33 Baumé, flash point of 380 deg. F., fire test of 420 deg. F., with a viscosity of 140 S. at 100 deg. F. The same quantity as before, two drops a minute, was used in a 14 x 14-in. cylinder, speed 150 r.p.m. This oil was used for years without any trouble from the standpoint of lubrication, valve leakage or carbon deposits.

The Oil Salesman's Warning

The oil representative made his regular calls and each time was informed of what was being done. He assured us that we were on the wrong track and that sooner or later we would get into trouble. But after continued tests and careful observation of all conditions, we are satisfied that the oil we are using is the most suitable for air-cylinder lubrication when working against 100 lb. pressure, either single- or two-stage.

One day an old friend called, who also happened to be an expert representing one of the leading oil companies. After learning of our experience with air-cylinder lubrication, he too made the assertion that we were using the wrong oil and said, "You know you get not less than 400 deg. F. in the air cylinder when working single-stage against 100 lb. pressure." With this we agreed and asked him how he knew we were wrong and what means he employed for ascertaining the proper grade of oil for air-cylinder lubrication. He then proceeded to explain the method their engineers use in determining the proper oil for different kinds of service. He said:

> Since you have agreed that the temperature of the air is 400 deg., our test would be conducted as follows: Take a block of cast iron 6 or 8 in. square and 2 in. thick, place this in a layer of sand in a shallow iron pan, pack the sand closely around the block, then put a gas burner under the pan and turn on the heat slowly. The top surface of this

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block is polished and has a drilled hole, and into the hole a thermometer is inserted. Heavy steam-cylinder oil is poured into the hole around the thermometer bulb so as to make a close heat contact. When the thermometer rises to 400 deg., lower the gas burner until the thermometer remains steady at 400 deg. Then take the different samples, dip the point of a lead pencil into the oil, hold the pencil two inches from the surface of this iron block and allow a drop to fall on the hot polished surface.

When such a test is made with the grade of oil from which you are getting successful results, the drop spreads out to about 1⅛ in. diameter, smokes a little, dries up, and is evaporated in 10 seconds, leaving the surface perfectly dry. With a higher grade of oil having a flash point of 450 deg. F. and heavy viscosity, when the drop falls on the surface of this polished block, it spreads out to about 1¼ in. diameter, smokes a little, but after five minutes the surface is still oily. Thus proof is offered that this is the proper oil to withstand the service in the air-compressor cylinder.

Temperature of Cylinder-Wall Surface

Upon being questioned as to the temperature of the surface of the cylinder wall when that of the air in the cylinder was 400 deg. F., he hesitated, but believed it would be about 25 deg. F. less than the temperature of the air. This did not seem right, as a water-jacketed wall should be much cooler than the air, so we went into the office and consulted some authorities on the subject. Some tests were found that had been made abroad on the temperature of the cylinder walls in an internal combustion engine, where with an explosion temperature of 2700 deg. F. and an average temperature through the cycle of 950 deg., with the water in the jacket at 200 deg., the inside surface of the cylinder wall did not go above 267 deg. Upon viewing these figures, my friend admitted that he had never thought that the temperature of the wall of an internal-combustion engine cylinder, with an explosion temperature so high, could remain as cool as this authority stated. However, since the character of the authority could not be questioned, the data were accepted by the oil expert, and his opinion as to the temperature of the air-cylinder wall, when that of the air did not exceed 400 deg. F., was revised to the extent that he did not believe it would be much above the temperature of the water in the jacket.

As a matter of fact, the temperature of the inside of the cylinder wall of a water-jacketed cylinder is not more than 30 deg. F. higher than the temperature of the jacket water, as long as the water does not boil; and since this is the true condition, why use oils of low gravity, high fire test and high viscosity? The temperature of the inside surface of the cylinder wall on an air compressor is little, if any, above the temperature of the surface in the main bearing of the ordinary Corliss engine.

True Conditions Unknown to Ordinary Expert

It would appear that the ordinary oil expert, who lays such stress on high viscosity and high flash point, has not considered the true conditions. It has been shown in this article that the cause of carbon deposits in the passages of an air cylinder is not always entirely chargeable to the residuum of oil, but in many instances is due to using an oil of too heavy body, which adheres to the passages of the cylinder; and furthermore, when the inlet is not properly protected from foreign matter, all such material as coal dust, mineral ash, shavings, waste, etc., is drawn into the cylinder and deposited on the sticky surfaces coated with this heavy oil. This foreign matter, with additional oil, gradually builds up until the passages become choked; the air valves begin to leak for some reason, thus increasing the temperature until it sometimes reaches a point as high as 500 deg. F. when compressing single-stage to 100 lb. If many shavings or much coal dust is deposited in the passages, the collection is apt to char and become incandescent. When it does, the temperature of the air rises rapidly, and as a consequence the pressure increases to a point beyond the strength of the receiver, resulting in what is generally called an explosion. It is the writer's opinion, however, that no violent explosion ever takes place in the ordinary air compressor, unless kerosene, gasoline or some such material is introduced into the compression space.

In a personal experience some years ago with a two-stage compressor where the intake had been neglected and also the wrong grade and quantity of oil had been used, the high-pressure discharge valves became leaky, thus allowing the air to churn in and out of the cylinder at each stroke, heating it until it became so hot that the heavy deposits in the passages actually took fire. The whole system burned out, like a chimney of an old-time wood stove. Fortunately, however, there was no explosion because the safety valve on the receiver relieved the sudden pressure caused by the burning material in the discharge passages and the compressor was promptly shut down before anything serious happened.

A Pure Mineral Oil Should Be Used

From the foregoing it will be understood that in the selection of an oil for air-cylinder lubrication, nothing should be used but a pure mineral product having a gravity of from 31 to 33 Baumé, a flash point of 375 to 390 deg. F. and a viscosity of 140 to 150 S. at 100 deg. F. Under no circumstances should a heavy grade be used, despite whatever claims may be made by the oil salesmen as to the virtues of heavy viscosities or high flash points. It should also be borne in mind that when the surface of the cylinder wall is once glazed over, little oil is required to adequately lubricate the working surfaces.

The film of oil on the cylinder wall is understood to be less than 0.00025 in. thick and since in the operation of compressing air there is practically no moisture, the piston rides back and forth on this film and requires little oil to be added to maintain lubrication. Should a greater amount of oil be used than just enough to keep up the required film, it will be plowed up ahead of the piston and be forced through the valves and into the cylinder cavities, where it will collect in the low places and solidify by reason of being mixed with foreign matter taken in through the inlet, forming deposits commonly called carbon.

As has been shown, a 14 x 14-in. cylinder can be adequately lubricated with two drops of oil a minute when the compressor is operated at 150 r.p.m., this being the equivalent of one drop of oil for each 641 sq.ft. of cylinder surface swept by the piston. The oil herein referred to happened to be of paraffin base. However, it is believed that an oil of about the same consistency, refined from an asphalt base, would serve as well, if not better.

Visits of Inspector Brown—XXXIII

By J. E. TERMAN

A continuation of the discussion on economizers. The Chief explains the different methods used for passing the water through an economizer. How explosions take place and how the connections should be made.

IF BROWN had not received such good training under the Chief, he might have been tempted to neglect some of the inspections which he had to make on this day, for he was eager to get back to continue the discussion on economizers. As soon as he reached the office, he went into the Chief's room and announced that he was ready to proceed with the circulation in, and connections for, economizers.

"Well," said the Chief, laying aside the reports he was looking over, "we were starting to talk about the circulation in economizers when we knocked off yesterday. As I said then, there are a number of different methods used for passing the water through an economizer. The method with the two kinds of economizers you will meet will vary with respect to circulation. Often an economizer of one of the types consists of a series of sections connected together at one end of the top and bottom headers, like this," said the Chief, drawing Fig. 1. "With such an arrangement it is customary to have a few of the sections at the entrance end separated from the rest. The water is brought in at the top manifold connection, at *A* and allowed to flow down these particular sections and then up the other sections in parallel; that is, flow up through all the remaining sections together. A division *C* in the upper manifold connection separates the few sections used as an entrance group from the remainder of the sections when the circulation is arranged in this way. Instead of having the entire economizer operating as a single group, it may be divided into several groups. In this case, divisions like this," said the Chief, indicating *C*, Fig. 1, "are placed in the manifold connection, so as to direct the water up and down the alternate groups of sections in passing through the economizer. The groups may be separate and distinct, and the water may pass in series through the various groups, with the flow always up through the tubes. With one type of economizer it is customary to circulate the water in series through a number of small groups, the flow being alternately up and down the various groups, as I have just explained."

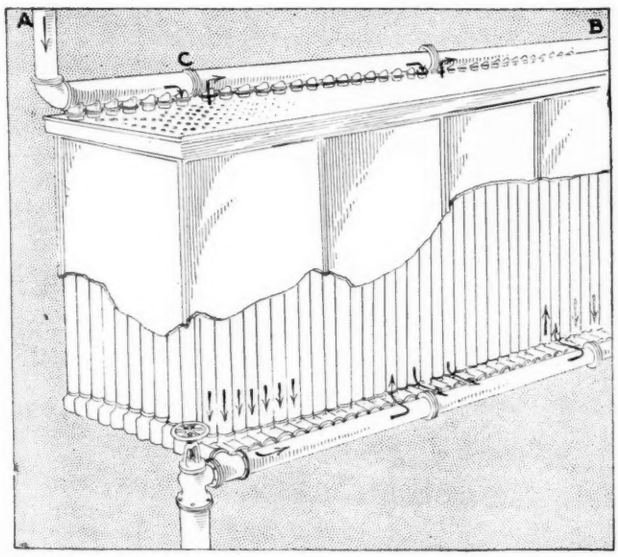


FIG. 1. HOW THE WATER PASSES THROUGH ECONOMIZER

"What advantages are to be gained by these various arrangements, Chief?"

"That is hard to tell, Brown. Where the flow is in series through a number of separate groups, the true counter-current principle is obtained, but it is at the expense of considerable internal friction. This friction loss is generally of more importance than any gain that may be hoped for from the more rapid circulation or the more gradual increase in temperature of the water passing through the economizer.

How Economizer Explosions Occur

"Now, Brown, we are coming to the external water connections for an economizer; that is, those which are not actually a part of the economizer. I want you to pay particular attention to what we are going to talk about, for this is the most important part of our discussion, as far as the safety of economizer operation goes. Before we start to talk about these connections, it may be well to discuss how economizer explosions take place. In this way you can better understand how important the external connections to an economizer may be, as far as its safety is concerned. If you were trying to remove a header from the tubes of an economizer by means of heat, how would you proceed, Brown?"

"Well, I have never had any experience, Chief, with this particular job, but I once had to remove some old carwheels from an axle on which they had been pressed. There was no wheel-press available to do the job, so I heated the wheels, axles and all, in a fire. After they were quite hot, I cooled the axle by putting pieces of wet waste on it, keeping the waste cool by cold water. In a short time I was able to pull the wheels off without much trouble."

"Well, that is just the way you would try to take an economizer header off the tubes, Brown. The only difference would be that if you were trying to do the job on an economizer under pressure, you would not have to bother about separating the header and the tubes when the connection between them became loose. The internal pressure would attend to that."

"Gee! Chief, that is so. I guess it is quite important that the headers don't get hotter than the tubes."

"You can just bet that it is," said the Chief; "and the surest way of getting the headers hotter than the tubes is to have them filled with air or steam and the tubes with water. Of course," continued the Chief, "if the water is not at a high temperature, say, not over 250 deg., the separation of the headers and the tubes will not

be a very serious matter. Where the temperature is high, as is of course the case where an economizer is steaming under pressure, the large volume of hot water contained is a regular magazine of energy. Under such conditions you may expect the things to happen that do happen when one of these otherwise harmless pieces of apparatus starts on a rampage. You can see that the main object in life for those who have to do with the operation of economizers should be to keep them cool. I intend to use 'cool' in a relative sense, Brown, for I mean that an economizer should be kept cool with respect to the temperature of steam of a pressure corresponding to that at which the economizer is operating."

"But, Chief, I thought that steam was always of the same temperature as the water from which it was being evaporated," said Brown.

"That is so, but we are not concerned with the internal temperature in this case. What happens when steam fills the top headers of an economizer is this: The heat delivered to the top headers by the hot gases is not transmitted to the contained steam nearly so fast as the heat delivered to the tubes is transmitted to the contained water. The result is, as you can see, the headers must become hotter than the tubes."

"Then it is a question of temperature rather than pressure; isn't it? If the water wasn't over 212 deg., none of it would change to steam and there would be no explosion if the header did come off under the pump pressure. But when you get pressure and temperature too is the time you have got to watch out."

"Yes; but the pressed joints will hold enormous pressures so long as they are kept tight. It is only when the economizer is so installed and operated that its contents can heat up to 250 deg. or over with the headers bare of water. It can do this when gas is passing through it, but little or no water, and that is what you inspectors want to provide against.

Effect of Connections on Overheating

"Now, to get back to how the connections to an economizer may have a bearing on the possibility of its being overheated. If a given quantity of heated gas passes around the tubes of an economizer and these gases have a constant initial temperature, it stands to reason that there must flow through the tubes, at least, a certain quantity of water of a given entrance temperature, if a steaming condition is to be avoided. In any economizer installation operating under usual power-plant conditions, if the economizer passes all the water required to be fed to the boilers which supply the gases for it, a water temperature cannot be reached that will cause steaming. Do you remember, Brown, the calculation we made before, to show the work that could be done by an economizer, and to show what the final temperature of the water leaving it might be?"

"Yes, Chief, I do remember that; you got the amount of heat delivered to the water from the weight and change in temperature of the gases flowing through the economizer."

"Well, then, we will work out another case, in which we will assume the temperature of the gases furnished the economizer is constant at 550 deg. F., but we will suppose that the exit-gas and entrance-water temperatures are varied. We will assume that the difference between these last temperatures is to be constant, at 180 deg. With fuel of 14,000 B.t.u. per pound, a boiler efficiency of 70 per cent., and a boiler pressure of 150 lb.; if the exit gases from the economizer are at 300 deg. F., the entrance water to the economizer under the assumed conditions would be 300 — 180, or 120 deg. F. We will assume, as we did in the other case, that there would be 22 lb. of gas per pound of coal burned and that the specific heat of the gases produced by this combustion would be 0.24. Since it requires 1105.5 B.t.u. to turn a pound of water at 120 deg. F. into steam at 150 lb. pressure, the number of pounds of steam made by a pound of coal under the assumed conditions would be $\frac{0.70 \times 14{,}000 + 22 \times 0.24 \times (550 - 300)}{1105.5}$ or 10.05 lb.

"Again, assume that the exit gases are at a temperature of 392 deg. F., corresponding to a water-entrance temperature of 392 — 180, or 212 deg. under the assumed conditions of operation. In this case the amount of evaporation would be $\frac{0.70 \times 14{,}000 + 0.24 \times 22 \times (550 - 392)}{1012.6}$ or 10.50 lb. of steam. The reason that the denominator is 1012.6 instead of 1105.5 as before is because of the change in entrance temperature. It requires 1012.6 B.t.u. to evaporate a pound of water from a temperature of 212 deg. F. into steam at 150 lb. pressure. In the first case we have heat furnished by the economizer of $22 \times 0.24 \times (550 - 300)$, or 1320 B.t.u. The exit temperature of the water from the economizer under these conditions would be $120 + \frac{1320}{10.05} = 251.2$ deg. in the first case, and $212 + \frac{834}{10.50} = 291.4$ deg. F. in the second case. The higher temperature in these two cases would correspond to a steam pressure of about 44 lb. Now, I don't want you to get the idea, Brown, that the figures we have made are just the ones that would be found in an actual installation; for we have omitted to consider quite a number of factors that would have a bearing on the case, but these would all tend to make the actual temperature of the exit water less than the figure shown by our calculation. Since it is not customary in power-plant operation to have water of as high a temperature as 212 deg. F. to feed to the economizer, and the temperature of the exit gases from the boilers is under rather than over 550 deg. F., it would seem safe to assume that if all the water required by the boilers that furnish hot gases to an economizer passes through the tubes of the same economizer, there is no chance of a steaming temperature being reached. Assuming that we are right up to this point, the thing needed to produce safety against steaming in an economizer is to see that these required conditions are fulfilled."

"That is certainly something worth knowing, Chief. I feel sure that if the operating engineer fully realized these facts, we could count on his taking particular interest in seeing that all the water required by the boilers does go through the economizer."

"Yes, Brown, you can count on the engineer if he is fully alive to the many different ways that water may get by the economizer into the boilers. There must be no parallel operation, that is sure."

"What do you mean by parallel operation, Chief?"

"This," said the Chief, drawing Fig 2. "You see, Brown, water comes into each of the economizers and after passing through them it is delivered to each end of a common feed main which serves all eight boilers. In the event of a valve being closed on a pipe leading to or from either economizer, the feed water required by the boilers would still be supplied through the other economizer and the attendants would be none the wiser until something happened. The mere difference in the

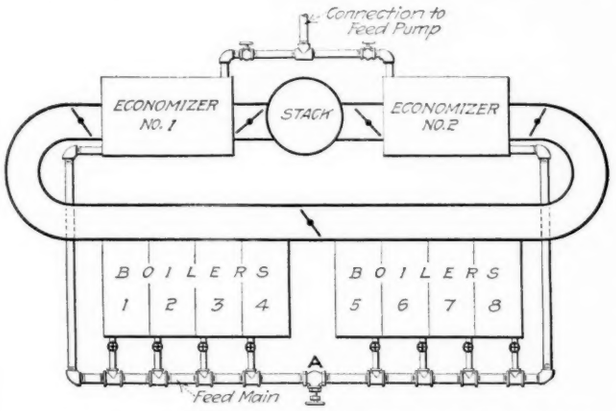


FIG. 2. SHOWING PROPER ARRANGEMENT OF PIPING

friction through the two paths that lead from the feed pumps to the boilers, in such an installation, is often sufficient to cause overheating and sometimes water-hammer action. This is a most dangerous condition and must always be remedied at once. The safest way to change a layout like this," indicating Fig. 2, "is to cut the feed line into two separate parts at *A*. You should always recommend that such a change as this be made, Brown, but you will often have severe opposition from the plant owner, who will want to run one economizer on all the boilers at some time. That is, with No. 1 economizer idle, he will want to run boilers from 1 to 4 on the No. 2 economizer. This may be arranged by placing a valve at *A* instead of absolutely cutting the feed line apart at this point. Wherever an arrangement of this kind is in effect, you should caution the operatives that the valve *A* must be closed at all times unless only one economizer is being used. If you can get the engineer fully convinced on this point, there is not likely to be any trouble. It is more important to have the valve *A* closed when operating the two economizers than it is to have the safety valve free," said the Chief.

"Say, Chief, I know a plant now where that sketch almost exactly applies, and they run with valve *A* always open."

"All I can say to that, Brown, is that I can lead you to several plants where they did run that way before their big lesson in economizer experience came, and I am sorry to relate that in some of them we paid for the experience."

"I will certainly look out for economizer connections, in the future, Chief."

"That is not all, Brown; economizers may be paralleled in other ways. An economizer is usually provided with a bypass connection, so that water may be supplied to the feed main when the economizer is out of service. It would not be right to ask the plant owner to shut down his boilers merely because he had some trouble with his economizer. Having the bypass valve open when heated gases are being passed through the economizer is most dangerous. The frictional resistance through the bypass connection is almost certain to be much less than that through the economizer; and even if the valves to and from the economizer are open at the same time, most of the water will flow through the bypass connection. Under such conditions the small supply of water flowing through the economizer may not be sufficient to keep the temperature down—the all-important feature in safe economizer operation. You will notice that I keep repeating this temperature thing, Brown, because I want you to get that firmly fixed in your mind.

How Bypass Connection Should Be Arranged

"You will notice that the miss-manipulation of the bypass valve will render a single economizer unsafe, while paralleling by other means applies only to installations where there are two or more economizers. It is getting late again," said the Chief, "but before we stop this evening I want to tell you how I think a bypass connection should be arranged. Since the bypass valve should never be opened unless some happening has occurred to require the closing of the valve leading from the economizer, I think these two valves should be located together. They should be preferably so arranged that the opening of one will interfere with the opening of the other, unless the opposite valve is closed.

"For instance," continued the Chief, "suppose the two valves are of the outside screw-and-yoke type, they might be arranged like this," drawing Fig. 3. "Valve *B* is open and water is flowing through the bypass to the boiler, because something has occurred that made it necessary to cut out the economizer. When the economizer is to be again placed in service, the engineer will come to open valve *A*, and his attention will be at once called to the fact that it is necessary to close valve *B* before opening *A*. To make doubly sure that no misunderstanding can exist as to how the valves are to be handled, valve *A* should carry a tag reading, 'This valve must be open when flue gases are passing through the economizer,' and valve *B* should be tagged in a similar manner, with, 'This valve must be closed when flue gases are passing through the economizer.' With such an arrangement it would seem that only full members of the 'bonehead' lodge or a blind man could go wrong."

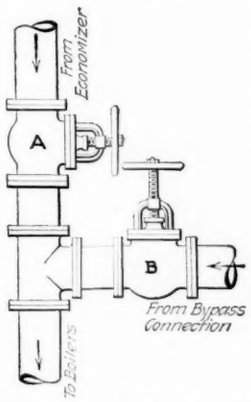


FIG. 3. PROPER ARRANGEMENT OF BYPASS CONNECTION

"Say, Chief, just what do you mean by the word 'full,' in connection with the bonehead lodge?"

"You can take the meaning as in reference to the condition of the member or to his membership; it goes either way," said the Chief.

"Well, good night, Chief, I will be in some time soon to get another dose of this spring tonic to be used in connection with economizer inspections."

The Electrical Study Course—Types of Motors

Deals with the three classes of direct-current motors in common use and explains the peculiarities exhibited by them. Also shows how these peculiarities adapt the different types to various classes of service.

SINCE any generator may be used as a motor it would be logical to conclude that there are as many types of motors as there are of generators, and such is actually the case. To recapitulate, we have the following types: Shunt, series and compound. In the last-mentioned type that part of the field winding which is in series with the armature may be designed for any

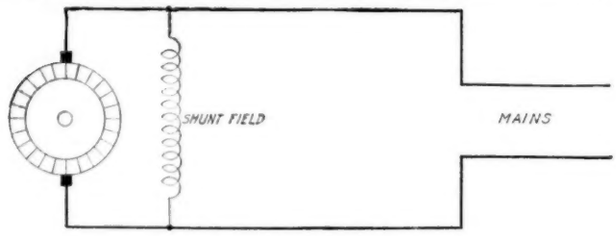


FIG. 1

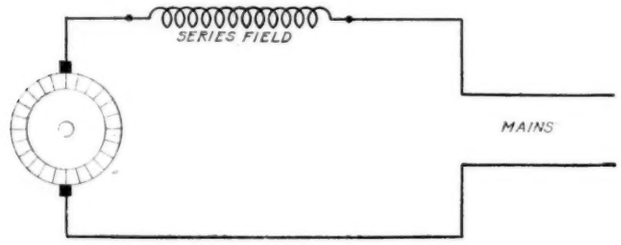


FIG. 2

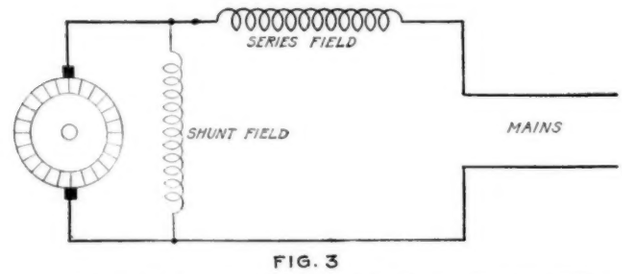


FIG. 3

FIGS. 1 TO 3. DIAGRAMMATIC CONNECTIONS FOR VARIOUS TYPES OF MOTORS

degree of compounding, as in the generator of the same type. As in generators also, interpoles are used to improve commutation and reduce armature reactions.

Each type of motor has its own characteristics, which fit it for one kind of service or another. For example, the shunt motor suffers only a slight decrease in speed when loaded, whereas the speed of the series motor decreases considerably upon increase of load. The compound motor is, of course, a combination of the shunt and series types and the relation between its change of speed and the amount of load on it depends on the degree of compounding. If only slightly compounded, it will practically be a shunt motor and the speed will decrease but slightly with increase of load. If heavily compounded, there will be a marked decrease in speed, but under no conditions will the decrease be as great as in the series motor.

It will be found interesting to examine into the causes that govern the changes in speed occasioned by changes in load which characterize the various types of motors and how these and the other characteristics which they possess adapt them to different kinds of service. In the previous lesson it was found that the speed of a motor is dependent on its counter-em.f. which automatically regulates the current to the needs of the load imposed on the motor. It was shown at the same time that the counter-em.f. is affected by changes in field strength and that consequently such changes affect the speed of the motor. Applying these facts to the various types of motors, we can readily come to an understanding of their respective behaviors.

The most common of the types is the shunt motor, and it is the one which maintains the most nearly uniform speed under all conditions of load. While in operation, it is connected to the mains as in Fig. 1. Since the field winding is connected to the mains, the field current will be constant and consequently the strength of the magnetic field will be constant at all loads, barring a slight difference due to armature reactions. Upon being loaded, the speed will therefore drop only by the slight amount required to allow just so much additional current to flow as will take care of the load. That the decrease is small was explained in the last lesson, where it was shown that current equals

$$\frac{\textit{Applied voltage} - \textit{counter-em.f.}}{\textit{Armature resistance}}$$

In general the speed of a shunt motor will change by about 10 per cent. from no load to full load.

The series motor while in operation would be connected as in Fig. 2, and in it the field current will increase as the armature current increases due to increase of load. Consequently, the strength of the magnetic field will be increased. In the previous lesson it was shown that when the field strength of a motor is increased its speed will be decreased, owing to the fact that the necessary counter-em.f. can be generated at a lesser speed. If the increase in load be great, the increase in current will be great and the decrease in speed will accordingly be very marked. Shunt motors may be operated at no load without encountering any difficulty, but series motors may not, which is a fact that cannot be overemphasized. The result of attempting to run such a motor at no load is to cause it to accelerate at a tremendous rate and very quickly to reach a speed that will cause the mechanical destruction of the armature, due to centrifugal force, in precisely the same manner in which the flywheel of an engine will burst if the governor fails and allows the engine to "run away." The usual consequence of such "running away" in the case of a motor is that the armature coils are thrown out of their slots, are jammed in between the field poles, being badly mutilated, and causing short-circuits within the windings, which add to the mechanical destruction. The cause for such excessive speeds is quite evident if we bear in mind that in a series motor the field strength is dependent upon the current taken by the mo-

tor. Suppose that a series motor is driving a load and that for some reason the load is removed. The current required to drive the motor at no load is very small, and in order to reduce the current to that value the motor automatically increases its counter-em.f. by speeding up, but as soon as the current begins to decrease the field excitation is reduced and consequently the strength of the magnetic field. This would tend to reduce the counter-em.f. instead of increasing it, and consequently the armature would have to speed up still further in its attempt to increase its counter-em.f. to a value high enough to limit the current to the necessary value. The smaller the current becomes the less magnetic flux will there be and therefore the greater the speed. The current that would be required by the motor running idle would be so small as to reduce the field flux to a very low value, and the armature speed required to develop the necessary counter-em.f. in such a weak field would be enormous. Considerably before such a value could be reached the speed would have passed the limit of safety provided in the construction of the armature. In the case of very small series motors, such as are used on desk fans, for example, the diameter of the armature is so small that even at high speeds the centrifugal force acting is not very great, and moreover, the speed is limited by the fact that the power required to run at no load is quite large as compared with the full-load current.

Connecting Compound Motors

Compound motors are connected as shown in Fig. 3 and, as already stated, their speed characteristics depend upon the amount of compounding. The influence of the series-field winding is similar to that in a straight series motor, but whatever excitation it gives rise to is only added to the constant excitation of the shunt field and is therefore only a minor part of the entire excitation in this case. Thus at no load there is only a slight amount of magnetic flux present, due to the series-field coils, but the shunt-field flux remains unchanged and the motor therefore is operating practically as a shunt machine. As load is placed upon it the series-field current increases, thereby increasing the entire excitation and accordingly causing the speed to drop to a value lower than it would if the motor were operating as a shunt machine. When compound motors are referred to, it is always understood that the series field is connected in such a manner that when the armature current flows through it the magnetic flux due to it will be in the same direction as the magnetic flux created by the shunt-field coils. If the series-field terminals were reversed, the current that flowed through the series-field coil would be reversed and hence the magnetic flux due to it would oppose the flux of the shunt field. A machine so connected would be termed a differentially compounded motor. It is an unusual type and one which it is hazardous to experiment with. It will operate satisfactorily at no load since the series-field excitation is small compared with the shunt-field excitation, exactly as in the case of the ordinary compound connection, but when load is imposed on the motor and the current that it takes increases in consequence thereof, the series-field excitation will be increased, but it will oppose the shunt-field excitation and hence reduce the total magnetic flux. The practical result is that the motor speeds up, thereby increasing the current it takes, due to increase of power required to drive the load at higher speed, and in many cases the series-field excitation becomes greater than that of the shunt field, thus actually reversing the direction of the field flux and causing the armature to reverse. That is, the armature will first increase in speed, then drop with great rapidity to zero speed and immediately begin revolving in the opposite direction. Usually, the fuses or circuit-breakers protecting the line will operate because the current reaches high values, but if they should fail to do so, as they might in the case of medium loads, the results are likely to be serious, owing to the reversal of direction of rotation. It is interesting, however, to make note of the fact that it is the only type of motor that increases in speed with increase of load.

In Fig. 4 are shown typical curves for the three types of motor that have been discussed. They show

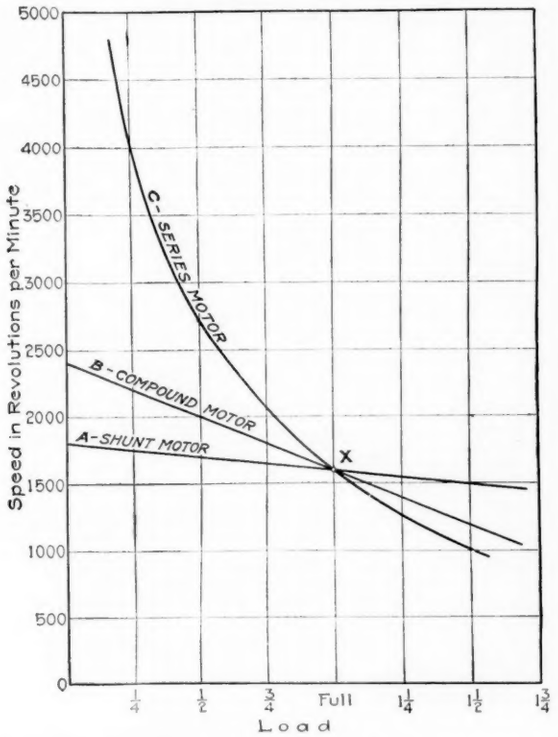


FIG. 4. CURVES FOR VARIOUS TYPES OF MOTORS REPRESENTING THE RELATION EXISTING BETWEEN SPEEDS OF MOTORS AND THE LOADS CARRIED BY THEM

the curves for machines of like size which have the same speed at full load, as indicated by the fact that the curves intersect at the point *X*, which shows that at full load the speed of each machine is 1600 r.p.m. The horizontal distances are laid off to represent the load on the motor and the vertical distances the speeds. Curve *A* represents the behavior of a shunt motor. The speed at no load is 1800 r.p.m. and that at full load 1600 r.p.m., indicating a drop of 200 r.p.m. Compare this with curve *B*, representing the performance of the compound type. Here the speed drops from 2400 r.p.m. at no load to 1600 r.p.m. at full load, or 800 r.p.m.; that is, four times as much as in the shunt. In the case of the series motor it will be noticed from curve *C* that no value of speed at no load is indicated. From the direction that the curve takes at its upper

extremity, it is evident that the speed would be enormously great at zero load. Even when carrying one-quarter of full load its speed is 4000 r.p.m., or 2400 r.p.m. more than its speed at full load.

Before considering the relation between the speed-load characteristics of a motor and its suitability for service of some particular kind, let us examine into the other features that must be taken into consideration. The pull that any conductor on the armature exerts depends not only on the magnitude of the current flowing through it, but also on the strength of the magnetic field in which it is situated. The entire force acting to turn the armature is called its torque and is expressed in the units in which force is usually specified; that is, lb.-ft. in the English system and gm.-cm. in the metric. The scope of these lessons does not permit taking up the matter exhaustively and consequently the reader will have to be referred to textbooks for any further study of the subject. It will suffice for the purpose of the present article to state that the power delivered by a motor is equal to its torque multiplied by 2π times its speed. If the speed is given in revolutions per minute, the answer will be in pounds-feet per minute. Since one horsepower is equal to the expenditure of 33,000 lb.-ft. of work in one minute, we would have, motor output $= \frac{\text{torque} \times 2\pi \times \text{r.p.m.}}{33{,}000}$ hp. It is therefore apparent that the output of a motor is dependent upon the torque, or force, tending to turn the armature, and upon its speed.

It should be clearly understood that the turning power, or torque, and the motor output are two entirely different things. For instance, a motor might be running at 1000 r.p.m. while exerting a torque of 52.55 lb.-ft., in which case it would be delivering an amount of power equal to $\frac{52.55 \times 2 \times 3.142 \times 1000}{33{,}000} = 10$ hp., while another motor, running at 500 r.p.m. might be exerting a greater torque, say 84.1 lb.-ft., and yet be delivering less power, as indicated by the following computation; namely, $\frac{84.1 \times 2 \times 3.142 \times 500}{33{,}000} = 8$ hp. That is, the pull, or torque, is dependent only on the armature current and strength of magnetic field, whereas the power delivered is dependent on the speed as well.

Often increase in pull or torque is the prime requisite of a motor, irrespective of variation in speed with load, and in such case the motor that would give the greatest increase for the least increase in current would be the most desirable. In other cases constant speed might be the chief condition to be fulfilled, and in such case the motor that most nearly maintained constant speed under variations of load would be the one to choose.

As already shown, the shunt motor belongs in the latter class, since it suffers the least change in speed as its load is varied, whereas the series motor would not serve at all. On the other hand, the series motor far excels the shunt motor considered from the standpoint of greater increase of torque for a given increase of armature current. The reason for this fact is quite simple. In the shunt motor the field strength remains the same regardless of the armature current, and since the torque is dependent upon both armature current and field strength, it follows that the torque increases in proportion to the increase of armature current. On the other hand, in a series motor the field strength is not constant; it depends on the current taken by the motor. We therefore find that when the load on the motor is increased, its field strength is increased at the same time that its armature current is increased, and consequently the torque increases much more rapidly than the current does. In the case of the compound motor we have a combination of the shunt and series machines in which the distinguishing characteristics of both are present in a modified degree. The speed changes more than in the shunt machine but less than in the series, whereas the torque increases more with increase of current than in the shunt machine but less than in the series.

Curves showing the foregoing relations graphically are given in Fig. 5. Curve *A* represents the relation

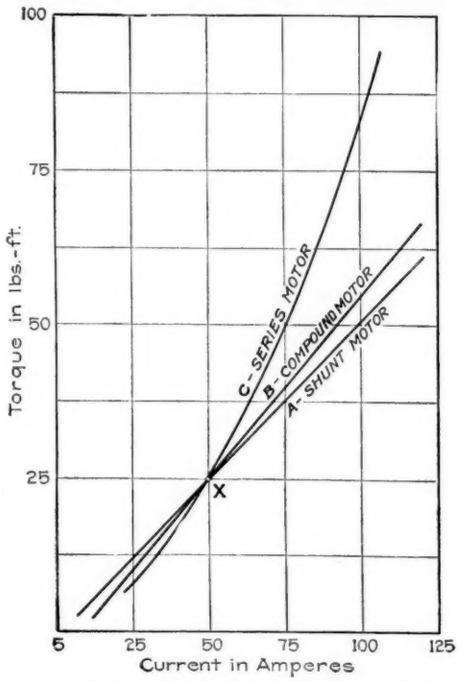


FIG. 5. CURVES FOR VARIOUS TYPES OF MOTORS REPRESENTING THE RELATION EXISTING BETWEEN TORQUES OF MOTORS AND THE ARMATURE CURRENTS TAKEN BY THEM

between torque and current in a shunt motor, curve *B* for a compound motor and curve *C* for a series motor. It is assumed that all three develop the same torque; namely, 25 lb.-ft. at a current of 50 amperes. The horizontal distances represent current in amperes and the vertical ones torque, or turning-force, in pounds-feet. It will be observed that the series machine undergoes a greater change in torque for any change in current than either of the other types.

With the foregoing information at hand we are now in a position to ascertain which class of motors is best suited for application to some of the more usual kinds of service which are generally encountered in practice. For loads requiring constant speeds the shunt motor is preëminently the best suited. The term "variable speed" applied to shunt motors should not mislead one into believing that the machine will change its speed of itself. A much better designation is "adjustable speed." Such a motor may be adjusted to

different speeds by means of suitable controlling apparatus, but once adjusted for any speed, it will maintain it within narrow limits until another adjustment for some other speed is made. Lineshafts, individual machine tools, such as lathes, drill presses, milling machines, etc., all require to be driven at as uniform a speed as possible. In fact, practically all factory use calls for that requirement, and where the service is direct current, the shunt motor is the one in almost universal use. On the other hand, the series motor finds its greatest field of usefulness in such applications as the driving of railway cars and the operation of cranes. Both these classes of loads require a strong pull or torque whenever they are to be started from rest and a rapidly diminishing torque as they pick up speed. Particularly is this the case in traction problems. It requires a very considerable amount of power to start a car or a train, but once brought up to speed it requires a comparatively small amount of power to keep it running. There is another characteristic of the series motor which makes it particularly valuable for such service; namely, that its speed increases greatly as the load upon it is decreased. A shunt motor would be impracticable for traction service owing to the fact that it is a constant-speed machine; that is, the car that it was driving could never attain a speed higher than that corresponding to the maximum speed of the motor, which would be its no-load speed. We could imagine the case of a car going down a steep hill. In that event there would be a minimum of load upon the motors and the car would reach its greatest speed. If driven by series motors their speed would increase as the load decreased and the car would be driven downhill at an increasing velocity. If, however, driven by a shunt motor, the car would soon reach the speed corresponding to the maximum motor speed, and no matter how steep the grade might be, it could never exceed this speed by any appreciable amount. As soon as it did exceed such speed, the car would actually be driving its motors as shunt generators and they would be furnishing power to the system. This would act as a brake upon the car and allow the speed to exceed the no-load speed of the motor by only a small percentage. It was pointed out that the load of a series motor must never be completely removed, and in the classes of service enumerated that condition is fulfilled; there is always some load on the motors, in consequence of which they can never run at an excessive speed.

Application of Compound Motors

The conditions governing the applications of compound motors are not quite so clear-cut as the other two types, but there are, nevertheless, well-defined uses for them. One of the most common is in connection with driving such machines as depend upon the energy stored in a heavy flywheel to help the motor or other driving agent at certain intervals. Power shears and presses belong to this class. It is only at the moment that the shear or die cuts through the metal or other material being worked with that the full load is placed upon the machine. It would require a large motor to operate such a machine if the entire energy required for the actual cutting or shearing were to be delivered by the motor at the instant that the action takes place; consequently, for the remainder of the time during which the machine was running the load on the motor would be very small and it would be operating very inefficiently. To overcome these drawbacks a heavy flywheel is resorted to, with the result that a much smaller motor may be used. Energy is stored in the revolving flywheel during that part of the operation which does not require the expenditure of much power, and when the cutting or shearing or stamping is to be done, the flywheel imparts energy to the machine. It can do so, however, only if the speed of the machine becomes less than during the remainder of the time. A shunt motor would keep the speed practically constant and consequently very little benefit would be derived from the use of a flywheel. A series motor would suffer too great a change in speed, causing an impracticable amount of variation in the operation of the machine. A compound motor designed to have the correct amount of series-field excitation would decrease in speed just enough to get the full benefit of the energy stored in the flywheel and yet not sufficient to cause any objectionable change in speed. It would, moreover, provide such increase in torque as was required at the instant of shearing or punching at a smaller increase of current than a shunt motor and therefore would be preferable from this standpoint also.

Solution of Problems of Previous Lesson

The problem given in the last lesson dealt with the counter-em.f. and losses in a 5-hp. 115-volt shunt motor whose armature resistance is 0.25 ohm, and whose efficiency at full and half loads is 85 per cent. and 70 per cent. respectively.

First, it is required to find what counter-em.f. would be generated at full and half loads. The full-load output of the motor is 5 hp. and its efficiency 85 per cent. Since there are 746 watts in one horsepower, we have $\frac{85}{100}\ W = 5 \times 746 = 3730$ watts, where W is the watts taken by the motor, from which we find $W = 3730 \times \frac{100}{85} = 4388$ watts. Let I represent the current taken by the motor; this will be equal to the watts taken divided by the applied voltage; namely, 115 volts, which gives $I = \frac{4388}{115} = 38.16$ amperes. We know that the counter-em.f. is equal to the applied voltage minus the voltage drop in the armature due to its resistance. That is, if R = armature resistance, which in this case is 0.25 ohm, I_a = armature current, E = applied voltage, in this case 115 volts, and e = counter-em.f., then $e = E - I_aR$. Except for the field current, $I_a = I$ and since the field current is very small in comparison with the full-load armature current, we may assume I_a to be 38.16 amperes. We now have $e = 115 - 38.16 \times 0.25 = 105.46$ volts. At half load the output is one-half that at full load, or $\frac{3730}{2} = 1865$ watts. The efficiency is 70 per cent., consequently in this case $\frac{70}{100}\ W = 1865$ watts, or $W = 1865 \times \frac{100}{70} = 2664$ watts. The current taken would then be, $I = \frac{2664}{115} = 23.17$ amperes and we would have $e = 115 - 23.17 \times 0.25 = 109.21$ volts.

We are further required to find the watts lost at each of the specified loads, due to the resistance of the armature. The watts consumed in any resistance are equal to volts times amperes, or in symbols, $E \times I$, and since $E = IR$, we can substitute IR for E, giving us, watts $= IR \times I = I^2R$. The armature resistance is 0.25 ohm and at full load the current is 38.16 amperes, therefore if W = watts lost due to armature resistance, we have

$W = 38.16^2 \times 0.25 = 364$ watts. At half load the current is 23.17 amperes, consequently $W = 23.17^2 \times 0.25 = 134.2$ watts.

In the last part of the problem it is required to find what current the motor would be taking if its counter-em.f. were 108 volts. Using the previous notation we know that $e = E - IR$, and substituting the known values we have $108 = 115 - I \times 0.25$, from which $I \times 0.25 = 7$ volts and therefore $I = \frac{7}{0.25} = 28$ amperes.

Water is to be pumped from a well 90 ft. deep into a tank situated 70 ft. above the ground, by means of an electrically driven pump. The tank is 8 ft. in diameter by 10 ft. high. The efficiency of the pumping system is 60 per cent. What size motor would be required to drive the pump if the tank is to be filled in 5 hours?

Oil-Cooled Transformer Cases

Ingot-iron sheets are used principally for the cases of oil-cooled Westinghouse transformers. To give the case a larger radiating surface, the sheets are first crimped. They are then welded together by an arc to

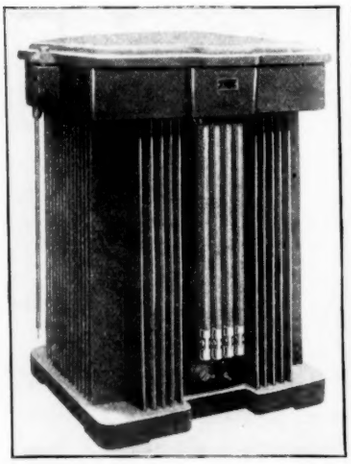


FIG. 1. CORRUGATED-CASE DISTRIBUTING TRANSFORMER

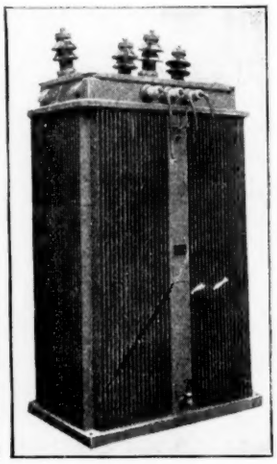


FIG. 2. CORRUGATED-CASE HIGH-TENSION TRANSFORMER

form a rectangular box without top or bottom. In welding, one terminal of the electric circuit is fastened to the material and the other to a holder in which is fastened a strip of scrap ingot-iron sheet. An arc is drawn between the material and the movable electrode and by the process of melting down the latter a continuous bridge of metal is formed. These joints are oil-tight and as strong as the remainder of the sheets.

To attach the bottom, the sides are held over a sand mold and molten iron is run from a furnace to the desired depth. An oil-tight and very strong joint is thus formed with the sheet-iron sides. The top casting is formed by inverting the case over another mold and allowing molten iron to run over it. The case contains the necessary openings for the transformer to be inclosed and for the entrance of wires.

One of the two general types of these transformers is shown in Fig. 1. It is used extensively as the link between the central-station distributing lines and the low-tension wires that enter the consumer's premises. These are generally installed outdoors; hence the use of rust-resisting ingot iron. They are built in sizes up to 200 kv.-a. and for voltages up to 33,000.

The use of rust-proof iron is a necessity, because a failure of one of these cases, due to rusting, would allow the oil to leak out rapidly, and as the transformers are not usually inspected, the unit might be subject to full load, with no oil to keep it cool. This condition would cause it to burn out in a few hours and create loss to the operating company, as well as give poor service or none at all to the customer.

Another type, Fig. 2, is used in sizes from 100 to 1500 kv.-a. up to the highest operating voltages. It serves as a link between transmission lines and large customers or distribution system. This type is also often installed out of doors.

Independently Driven Circulating Pumps for Jacket Water

The usual method of circulating cooling water through the water jacket of a large internal-combustion engine is by means of a pump, driven either directly or indirectly from the crankshaft of the engine. This construction is advantageous in that it produces a self-contained unit; but it likewise introduces a serious difficulty. When an engine drives its own circulating pump, the flow of cooling water begins as soon as the engine starts and ceases as soon as the engine stops. Since heat is developed only during the period in which the engine is in operation, it would seem, at first thought, as though the flow of cooling water should be made concurrent with the running of the engine; however, this conclusion is far from being logical.

The temperatures attained in the combustion chambers and cylinders of internal-combustion engines are high. In the case of oil engines, particularly those of the Diesel type, the pressures are very great, necessitating the use of heavy cylinders and pistons. As a result, a considerable weight of metal is comprised by the boundary walls of the combustion chamber and cylinder, and under the influence of the high temperature developed during combustion, a large quantity of heat is stored up in this metal, in spite of the fact that the outer surfaces of the walls are in contact with the cooling water.

When the engine is shut down, after a period of running at full load, and the water circulation simultaneously ceases, there is still sufficient heat stored up in the metal to evaporate the hot water in the jacket and leave an excess. This excess, of course, is conducted through the walls into connected parts that were not designed to withstand temperature stresses, and as a consequence they are strained or cracked.

Obviously, the easiest way to overcome trouble of this kind is to do away with the direct-connected pump and use an independent drive. Then, when the engine is stopped, the circulating pump may be kept running and water may be kept flowing through the water jackets until all the heat is removed and the metal is cooled to a normal temperature.

It is reasonable to assume that warping, seizing and cracking in the cylinders and cylinder connections of oil engines is often the result of the stoppage of water circulation before the heat has been dissipated.

Buckeye-Barrett Oil Engine

A heavy-duty horizontal two-stroke-cycle semi-Diesel engine using a crosshead has been recently placed on the market by the Buckeye Machine Co., of Lima, Ohio, from the designs of D. O. Barrett, for operating on low-grade fuel oils. The general construction is shown in Figs. 1 and 2. An unusual feature is that the air for combustion is taken in at the flywheel end of the bed and is carried back the entire length of the bed before entering the cylinder. During long continuous runs

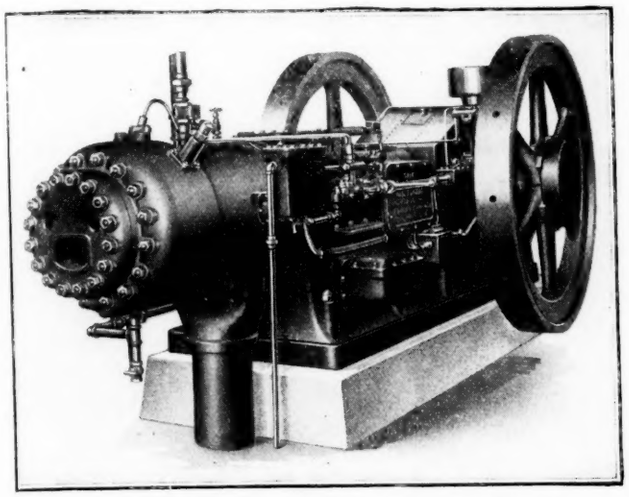


FIG. 1. BUCKEYE-BARRETT OIL ENGINE

some heat is naturally generated in the bed owing to the friction of the working parts, and the passage of this air in contact with the metal surfaces serves to absorb some of this heat and results in slightly warming the air for combustion and in cooling the bearings. The air valve through which the air enters the cylinders is bolted to the outside of the bed and may be inspected by removing the cover. This valve is automatically operated, and its position insures freedom from carbon deposits which might form. The exhaust ports are located in the bottom of the cylinder, and the burnt gases escape when the ports are uncovered by the piston. Fuel oil is supplied to the engine by a heavy bronze pump with steel valves and valve seats, the latter being renewable. The pump is bolted to the bed of the engine, and the fuel is supplied from an auxiliary tank placed above the level of the pump, so that the oil will flow by gravity to the suction valve, but being lower than the spray plug, oil cannot normally flow into the cylinder. The pump operates on the constant-stroke system, being driven by a cam on the governor-gear shaft. By means of a wedge controlled by the governor the amount of oil fed to the engine and that bypassed back to the auxiliary fuel tank is determined. The governor is of the centrifugal type, gear-driven from the mainshaft. It is assembled as a unit and mounted on the cam-case cover, from which it can be removed without dismantling any other parts. The engine may be stopped by opening the bypass valve or by holding the side rod out of engagement with the cam roller. A pump lever for hand use is provided so that the line may be readily filled at any time.

It will be apparent from Fig. 2 that the spray plug is inserted in the cylinder head at an angle so that the fuel is projected into the center of the ignition bowl. The plug is provided with an extra valve to prevent leakage or blowing back into the fuel line. A ground joint is arranged at the lower end so that the heat of combustion does not come in contact with the body of the plug, causing it to heat, as this naturally would cause the oil contained in the plug to vaporize, with a consequent rise in pressure and leakage. Ground union connections are also provided at both ends of the fuel line from the pump.

The vaporizing chamber, or ignition bowl, into which the fuel is injected, is bolted into the cylinder head and, by removing it, the interior of the cylinder and the ports may be inspected without taking off the cylinder head. The bowl is nearly spherical in form and is practically a separate chamber into which the fuel is sprayed, making it possible to keep all unvaporized fuel out of the cylinder proper. During compression practically all the air is forced into the ignition bowl, so that it comes into

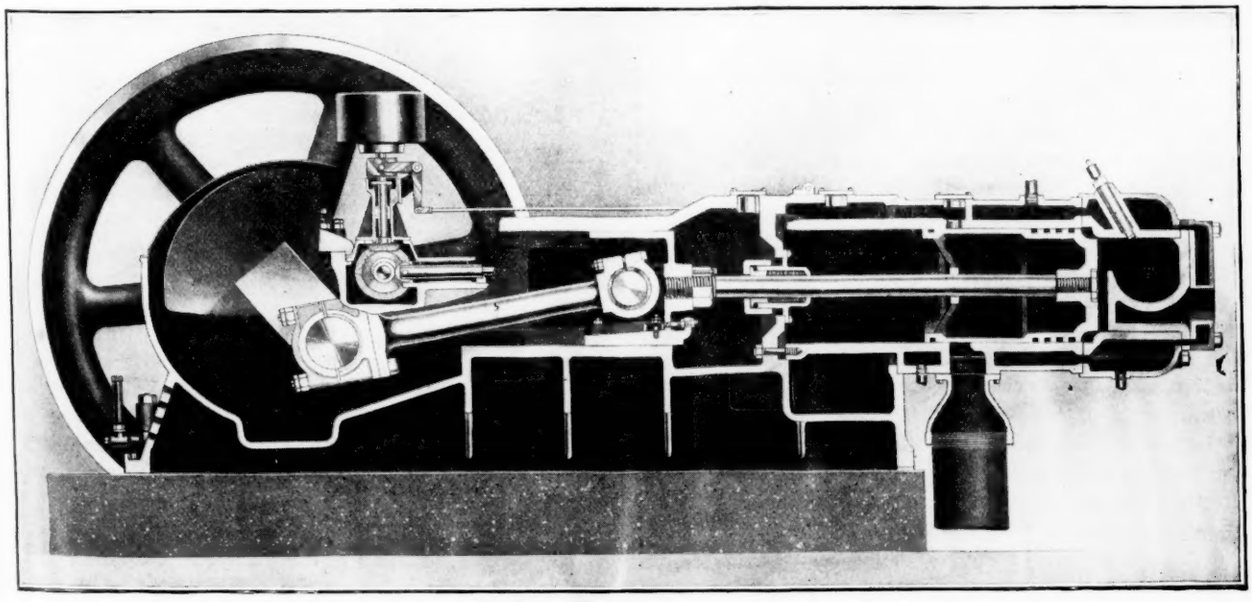


FIG. 2. SECTION THROUGH THE BUCKEYE-BARRETT OIL ENGINE

intimate contact with the gasified fuel. The greater portion of the bowl is uncooled and of such a form that free expansion and contraction are possible. Back of the bowl and supporting it is a separate water-cooled head which serves to keep down any excessive rise in temperature. A torch is provided to give the heat to ignite the first charge of gas.

Reference to the illustrations will show that the method of fastening the cylinder to the bed is new. The studs and nuts are placed on the inside of the bed, and the cylinder is held both at the center and at the end, so that alignment with the bore of the crosshead is maintained. The metal of the bed extends over the cylinder proper, giving added protection to the packing or gasket at that point. The stuffing-box through which the piston rod passes is bolted to the bed and is provided with a threaded gland which may be adjusted without removing either of the side plates.

To prevent undue expansion in the cylinder a large water space is provided around the working barrel. The water space extends around the exhaust ports. The water enters the cylinder at the hottest point just ahead of the exhaust ports, and a separate inlet pipe leads to the cylinder head, stop-cocks being provided in the line so that a uniform temperature may be maintained throughout. Overflow water from the cylinder jacket passes through an open funnel beside the cylinder. Warm water from the cylinder jacket is allowed to enter the jacket of the auxiliary fuel tank, which is bolted to the side of the cylinder. Warming up the fuel in this way permits the use of heavier oils than would otherwise be possible, and in cold weather does away with starting on a lighter fuel. The tank contains a strainer and another is placed in the main fuel-supply tank, to prevent dirt reaching the fuel pump. The auxiliary tank may be used either with a gravity system or with an underground supply tank.

The same style of joint is used between the cylinder head and the cylinder as between the cylinder and the bed; that is, the metal of the cylinder head actually extends over the cylinder. The construction of the cylinder head is unusual in that it provides for circulation of cooling water entirely around the cylinder-head studs, the purpose being to keep down undue expansion. Piston and crosshead construction is apparent in the sectional view.

A force-feed lubricator driven from the camshaft is attached to the side of the engine bed. Four feeds are provided, three for the cylinder and one for the governor. The crankpin is oiled from cups in the cap as well as from the oil rings. The crosshead and pin are also oiled from the splash, and a special sediment chamber is provided so that any condensation inside the case may be drained out without disturbing the main supply. The splash also flows over the main bearings from separate oil wells underneath. The same method is applied to the camshaft and the steel gears driving it. In the bottom of the bed a large well is provided so that an ample supply of oil may be carried. An oil gage insures that the oil is maintained at the proper level. An oil filter also forms part of the equipment.

To apply the power of the engine a special clutch mechanism and a pulley on an extension shaft supported by a pedestal bearing are provided. The heavy friction ring of the clutch may be bolted to either flywheel, and between the flywheel and the friction ring is provided space for a belt to operate the pump furnishing cooling water for the cylinder jacket. The clutch mechanism is of the expanding and contracting type provided with wooden shoes. It is of sufficient size for more than a 100 per cent. overload.

For the main engine the starting outfit consists of a small gasoline engine driving a compressor of the water-cooled type, but with the open jacket so that piping is unnecessary.

Stets Boiler-Feed Controller

In the description of the Stets boiler-feed controller, in the June 4 issue of *Power*, page 800, the impression may have been given that this controller maintains a constant water level in the boiler.

As a matter of fact the regulator does not maintain a constant water level at a predetermined height, but on the contrary, maintains a continuous flow of feed water in a working boiler, the water level being higher at light loads and lower at heavy loads. A study of the design of the controller shows that the water level will have to be high in order to throttle down the flow of water to the valve and the water level will have to be low in order to open wide the valve. At any point between these two extremes in the position of the float, the valve opening will be proportional to the water level and the quantity of water passing through the valve will be proportional to the opening or the area of the ports uncovered.

Purchasing Power Equipment

A sale of an endless belt for use in driving machinery implies a warranty on the part of the seller that the belt is of merchantable quality and suitable for the purpose for which it was to be used, holds the Mississippi Supreme Court in the late case of Lumbermen's Supply Co., vs. Poplarville Sawmill Co., 78 Southern Reporter, 157. But in the same opinion the rule is laid down that the failure of the buyer to take steps to secure a cancellation of the purchase within a reasonable time after discovering that the belt is defective waives any right to afterward repudiate liability for the whole purchase price. In other words, where there is a breach of an implied or express warranty as to the quality or condition of a thing sold, the buyer on discovering the defect is entitled to have his purchase canceled, by acting promptly. But his continued use of the thing in the face of knowledge as to its actual condition constitutes a binding acceptance of it.

The same general principle was applied by the Washington Supreme Court in the case of Shepard vs. Wexler, 170 Pacific Reporter, 133, in which it was decided that where a pump was sold under a conditional sale contract, reserving title in the seller until payment of the agreed purchase price, the buyer's continued use of the pump after discovering any failure on its part to come up to the specifications under which it had been sold, waived any right to return it; merely leaving him with a right to claim a deduction from the price of an amount equal to the difference between the fair value of the pump as it was represented to be and as it actually was.

EDITORIALS

Government To Take Charge

A WAR emergency bill authorizing the President to acquire, construct and operate power plants of all kinds, with a view to stimulating the production of material and commodities essential to the prosecution of the war has been drafted by the War Industrial Board and submitted to the House Interstate Commerce Committee. This proposed legislation is designed to take advantage of steam, as well as water power, during the war. In its present form the bill provides for compensation for property taken and also provides that the power to operate and maintain the plants taken over, or constructed, shall be exercised only for such time as the President may deem necessary or advisable in the interest of the United States.

Just how far reaching this power, if granted the President, will be is a matter of conjecture. It will doubtless mean that all the large power stations will be operated by the Government and that their output will be used for furnishing power to such industries as are directly or indirectly producing war materials. This all brings home to the operating engineer the necessity of improving boiler-room operation, and in many plants there is need of this. Even now there is at work among the power plants of the country a field force of engineers and inspectors, who are carrying out a campaign of instruction and inspection with the view of putting certain plants in condition to produce power efficiently, the slogan being "Maximum production with minimum of waste."

It should be the aim of every engineer to operate his plant so as to obtain the greatest capacity with the least expenditure of fuel. In a large number of plants it may appear that there is not much opportunity for making a saving. As is well known, the chief unavoidable losses in the boiler room are ashpit, draft, moisture in coal and radiation. However, a part of the ashpit losses can be avoided by careful handling of the fires, and other losses, such as those due to incomplete combustion, air infiltration, excess air admitted through the fuel bed, dirty heating surface, scale, steam and water leakages and radiation of steam pipes, can be materially reduced.

These losses may be small in themselves, and they may be taken by some as having little to do with the inefficient operation of the boilers. Remember, however, that every little leak adds to the grand total and that every leak stopped increases the efficiency of the plant

Although alteration to a boiler furnace costs money and there are some owners who will not go to the expense even if they know there will be saving in the end, the engineer can bring about better conditions by remedying existing defects that are within his province as an engineer and at practically no expense to the owner.

As has been stated in these columns before, a careful fireman will prevent the admission of excess air to the furnace and careful firing will greatly reduce the sifting of coal into the ashpit, where it is mixed with the ashes and then thrown out as refuse. The proper manipulation of the dampers will also assist in the combustion of the fuel. Suitable covering will reduce the radiation losses from pipings, boiler settings and boiler drums, and air infiltration can be reduced by stopping up the cracks in the setting.

Of course the only sure way of determining whether proper combustion is being maintained is to analyze the gases, and there are many small plants where the owner cannot be made to see that a CO_2 instrument would be a paying investment. However, thus handicapped, the operator can see that there is a draft gage and that the boilers are kept clean both on the fire and on the water side of the metal.

If every isolated steam plant were being operated at its highest efficiency (and this would mean a great improvement in many of them), the engineer would feel like giving the field inspector a glad hand when he arrived to inspect the plant and would be in a position to say, "Find something wrong if you can." How many can say that? How many plants are there that cannot be improved in one way or another that will save coal? Is your plant exempt from improvements that would cost next to nothing to make?

Mechanical Integrity

UPON one thing the business of mechanism has reason to congratulate itself, and that is that bribery and corruption are much less common than is usually supposed and far less frequent than in other quarters, if the evidence which is adduced from time to time is reliable.

It is perhaps not so much lack of desire as the fact that engineering is economics in actual practice and any dishonest payment reacts at least a hundred-fold in amount upon the efficiency of the job. For it is certain that the individual bribe carries an unfair profit to its tenderer and the payment, if made, is never commensurate considered as a bargain. This leaves aside altogether the ethics of the question and whatever risk of exposure there may be. No man of character, and more especially of experience, is likely to sell his self-respect for a mess of pottage. He might for a kingdom or his past youth, though there are many more than are usually suspected who would decline a throne purchased by backstairs influence, and more who would decline a fresh start to make past mistakes over again.

It is not alone fear which keeps men virtuous, nor are they honest merely because it is policy. Acceptance of a consideration restricts freedom, and it is pure stupidity, for some trivial advantage, to place another man's foot on your neck. Youth and inexperience may be tempted, though there is some protection in the fact that they are less hardened, while riper years can plainly see that a small personal gain is dearly bought at the sacrifice of freedom.

It is to the credit of engineering firms in general and engineers as a class that straight and upright dealing is the rule. No firm or man can in the long run survive unless intention and practice are honest.

There is, however, one factor not quite so well realized as it might be by the short-sighted, and this is, paying responsible technicians to whom selection is entrusted salaries which invite pilfering. The temptation to poverty is extreme and should be forestalled by more generous dealing. For example, the discoveries in the way of indispensable men before the military-service tribunals have been surprising in the matter of salary paid. At the present moment it is the responsible technician, the staff official who is underpaid by comparison with the manual worker, and such policy is very unwise. Either such a man must be trusted or another must be employed to watch him. An adequate salary removes any possible justification for the acceptance of consideration or bribe.

In another connection it seems little realized how strong is the resentment, in the common shop atmosphere, to oblique dealing. Those with actual shop experience know how unfair influence, crooked methods and favoritism are viewed by the inarticulate men lower down. It is solely a sense of right dealing which leads the workman to favor seniority at the expense of efficiency, when he chooses a representative or a leader from among his fellows. The more highly placed are at times aghast at his choice, but the impulse is commendable and does credit to feeling if not to intellect.

It is safe to say that there is an inherent sense of justice and right where a number of men associate on a common level, and straight and plain dealing carries weight in the handling of men.

Integrity is a valuable asset to foster, but its cultivation is to some extent neglected by those to whom it represents most.

An Admirable Fuel-Saving Bulletin

IT IS a pleasure to call our readers' attention to the bulletin on fuel saving just issued by the Advisory Engineering Committee to the New England Fuel Administration, from which extracts are printed on another page. Dr. Hollis and his associates, with the coöperation of Mr. Storrow and his staff, have done a fine piece of work in thus providing the power plant and factory, business building and central station, with so much practical material of war-time importance from the standpoint of coal using. The essentials of fuel saving as here set forth are none the less valuable because they are couched in nontechnical language; in fact, the appeal of the bulletin to the plant owner is likely to be all the stronger because of this. Again, the industrial plant fuel saving committee organization chart included in the bulletin, setting down as it does the duty of each important executive and committee member within a typical plant in fuel saving, gives the busy executive something tangible to turn over to his technical men and forms the starting point for a campaign which needs only the backing of many a plant owner to be pushed to enthusiastic success by his employees.

Every progressive engineer, fireman, master mechanic and electrician should be considered ex officio an ardent worker for efficient fuel consumption. If he is well posted, the suggestions contained in the organization chart will reinforce his efforts and confirm his practices. The value of these economic suggestions lies not so much in their novelty as in their general application. A lot of loose ends, however, are covered, which are sometimes overlooked, such as the systematization of drawings of plant and piping systems so that industrial-plant fuel-saving committee meetings need not be delayed; the preparation of lists of instruments needed in coal-saving as well as of instruments in regular service; the tagging of piping so that leaks, losses or breaks can be reported in writing and without misunderstanding; and the analysis of machine operations at intervals, for the purpose of reducing peak loads. All these points as covered in the bulletin bear directly upon the saving of coal as a war measure, and deserve the most thorough application. As the bulletin so well puts it, "Coal Economy or No Coal At All," is the situation that confronts many industrial plants today.

The Turbine Wreck at Northwest Station

A CURTIS turbine of 35,000-kilowatt capacity, single-cylinder, was wrecked July 31. This machine is of the latest type, having twenty stages; it is the same type of machine that was seriously damaged in the O Street Station of the Boston Elevated Railway Company late last February. A report of this accident appeared in *Power*, issue of March 19. In the recent accident at Chicago, pieces of the rotor broke through the casing, damaging the power house. We understand that there was no loss of life. W. L. Abbott, chief engineer for the Commonwealth Edison Company, owners of the station, puts the loss at one hundred thousand dollars, according to news reports.

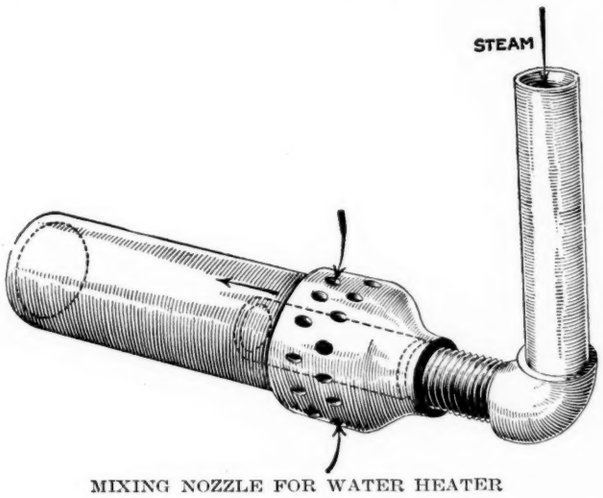
At this writing we have not yet learned authoritatively just what caused the accident. The turbine has not, we understand, been accepted by the purchaser, and the builders advise that they are not permitted by the purchaser to give out any information concerning the accident. We do not, therefore, want to conjecture about so serious a matter. Photographs of great technical value of the damaged machine have been taken, but as in the case of the Boston wreck, these will not, at present at least, be released for publication in engineering papers.

One wonders if the accident is a parallel to the Boston wreck; that is, if the initial cause of the accident was the same. The Boston machine went to pieces because the eighteenth diaphragm distorted and fouled the eighteenth wheel, this causing the following diaphragms to break and be thrown through the casing and power house. We do not know that this happened to the Chicago machine, but whether it did or did not, it begins to appear that the builders have reason to seriously consider the alteration of this design. The blades in the low-pressure stages are long, being twenty-eight inches, and the peripheral speed is nearly a thousand feet per second. We understand that the low-pressure casing was torn open at the extreme low-pressure end, indicating clearly that either a blade or some blades let go and were the initial cause of the wreck or that a diaphragm fractured or became badly distorted, as happened at Boston. Members of our staff are investigating the accident, and their reports will be published as soon as accurate information is available.

CORRESPONDENCE

Noiseless Liquid Heater

Anyone who has attempted to heat water by introducing steam directly into it through a nozzle knows the awful "racket kicked up" when the steam and water meet. A silent heater can be made as shown in the



MIXING NOZZLE FOR WATER HEATER

illustration and no extended explanation is necessary. In addition to the noiseless feature, this form of heater sets up a rapid circulation of the water, which causes it to become heated in a shorter time.

Guttenberg, N. J. L. V. LAUTHER.

Plastic Refractory Boiler Baffles

In the issue of June 11, page 838, a method of constructing horizontal baffles of refractory material is described. It seems to me that the top baffle could be constructed more easily by stretching cheap cotton cloth across the tubes. The distance the baffle extended down between the tubes could be regulated by the tension or slack of the cotton. My objection to the lower baffle is not so much the method of application as its effect on the boiler. For instance, by building the baffle up until it is in contact with the second row of tubes, the spaces between those tubes will form pockets into which soot will lodge, and it will be almost impossible to remove it except in cases where the tubes can be blown from the end as in the Heine type of boiler. This soot will insulate and diminish the capacity of the second row of tubes. It seems that a better way would be to build an arch independent of the tubes or suspend the baffle from the lower row. The latter method would probably reduce the tube failures from overheating. Better combustion would be one result, and that is what we are after in these days.

Will the manufacturers kindly inform us whether the material can be used in the way suggested or not?

St. Catharines, Ont., Canada. R. MCLAREN.

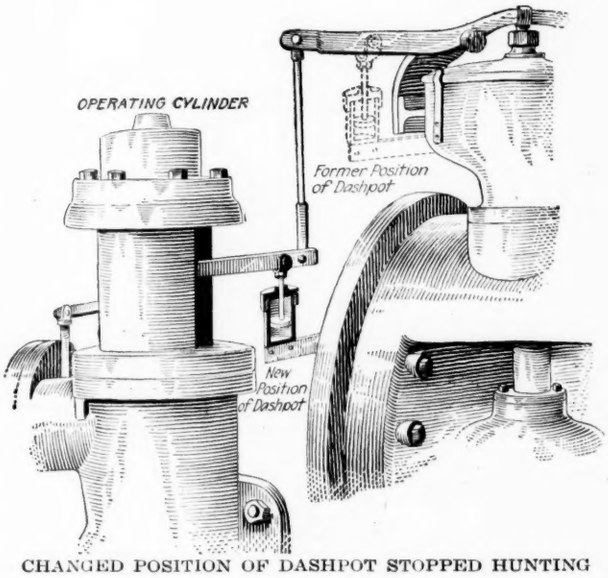
Fuel-Conservation Suggestion

The whole country is placarded "Conserve," and the electric-light industry is urged to save light and help save coal. It is just as important to save coal in power-house work in the summer as in the winter, and it seems to me that if the electric-light companies would cut down the minimum rate on electric light in the summer it would help, especially since comparatively little light is used. For instance, if companies whose minimum charge is one dollar would reduce it to seventy-five cents, I am sure it would help. Not long ago I heard a man say, when asked why he let a certain light burn uselessly, that he was not using his minimum allowance anyway and as he needed this light once in a while why then should he turn it off since it did not cost him any more to let it burn. If the minimum charge was cut to seventy-five cents, the chances are that the light would be turned off and fuel would be saved.

Norristown, Penn. WILLIAM H. WATSON.

Governor Dashpot Position Changed

A high-speed turbine caused considerable trouble by the governor continually "hunting" after the speed was changed to operate the generator at 62½ cycles instead of the original 60 cycles. At first the fluid in the operating cylinder was changed from steam to oil under



CHANGED POSITION OF DASHPOT STOPPED HUNTING

pressure, which helped some, but the regulation was still unsatisfactory at light loads. The position of the dashpot was then changed from the governor arm, shown in dotted lines, to the floating lever as shown in the illustration. This gave the dashpot more leverage and travel and overcame the hunting entirely.

Herkimer, N. Y. HAROLD G. BURRILL.

Reconnecting a 250-Volt Motor To Operate on 110 Volts

A sudden need arose for a series motor to operate on a 110-volt circuit at a time when none could be obtained for immediate delivery. A 250-volt motor was, however, to be had, and upon examination it was found that it could be rewound for 125 volts without much trouble, and it was therefore decided to do so.

The rewinding was accomplished as follows: The motor was a four-pole machine, having only two field coils connected in series for 220 volts, as in Fig. 1. All that was necessary to operate the field coils on 110 volts was to connect them in multiple, as in Fig. 2.

The armature was found to be of the series-wound drum type, with two turns to a coil and two No. 10 B. & S. wires in multiple. To convert it into a 125-volt winding and preserve the same capacity, it was necessary to reduce the number of conductors in series to one-half and to double the current-carrying capacity of the coils. By referring to Figs. 1 and 2 it will be understood how the change was accomplished. Fig. 1 shows the connections of the field and armature in the original state and Fig. 2 shows them after rewinding. By cutting the loop of each coil, as at *A*, Fig. 1 and bringing the long portion of the cut loop over and connecting it to the commutator bar to which the long lead of that coil is connected, as at *F*, and connecting the stub end of that loop to the bar to which the short lead of the same coil is connected, as at *G*, the coils are changed from two-turn, two-wire ones in multiple to coils of one turn and four wires in multiple, which accomplishes what was sought, namely, reducing the number of conductors one-half and increasing the current-carrying capacity by two.

The work of rewinding was not quite as simple as it appears from the description, since the top coils had to be lifted out of their slots in order to get at the bottom loops and leads. Fortunately, the loops of the

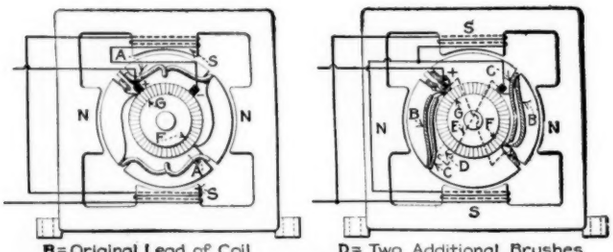


FIG. 1 FIG. 2

CONNECTIONS BEFORE AND AFTER MAKING THE CHANGES

coils were of such length, that when cut and made into leads they were long enough to reach to their respective connecting points. The slots in the commutator were not deep enough to accommodate all the additional leads, and the last two wires had to be welded to the segment outside of the slot, as shown in Fig. 3, by means of an oxyacetylene torch. After the rewinding was completed, the spaces between the wires were filled with very dry crushed asbestos and the entire connections were then taped and secured with a wire band.

After putting the motor in service, it was found that two brushes were not sufficient to carry the doubled current, and it became evident that additional brushes would have to be provided. The arrangement shown in Figs. 4 and 5 was therefore contrived. It consists of a cast-iron ring *A* turned up out of a suitable casting arranged to carry four sets of brushes instead of two as in the 260-volt motor, and another ring, or so-called yoke, *B* of ½-in. sheet steel, which had to be made in halves in order to get the tongue on it into the groove of ring *A*, the halves being welded together when in place with the oxyacetylene torch. This new brush-

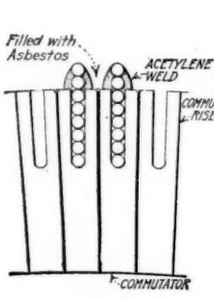


FIG. 3

WELDING WIRES TO OUTSIDE OF SEGMENT

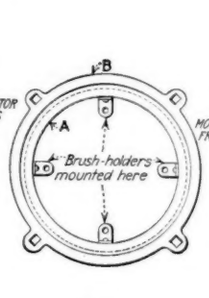


FIG. 4

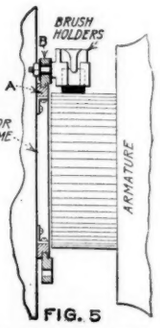


FIG. 5

NEW BRUSH-HOLDER FRAME AND METHOD OF FASTENING IT

holder frame was secured to the frame of the motor, as illustrated in Fig. 5, which also shows how the brushholders were insulated from the holder frame with wooden washers.

It took two men one and one-half days to complete the entire job.

Winona, Minn. V. T. KROPID.

[Although the scheme described by Mr. Kropid accomplished the change from 250 to 110 volts, a simpler way would have been to change the armature winding from a series to a parallel connected.—Editor.]

Static Electricity from Gasoline

In connection with the discussion of static electric discharges from various causes, (see page 130, Jan. 22; page 232, Feb. 12; pages 592 and 594, Apr. 23 and page 521, June 25) it may interest readers of *Power* to know that a fire causing damage to the extent of some $50,000 occurred recently in the plant of the Imperial Oil Co., started by a spark of static electricity at the nozzle of a gasoline tank that was being emptied into a tank wagon. Following is part of the report of the Provincial Electric Inspector:

> Explosions and fires under similar conditions have occurred at various times in the United States and in England, and the matter has been investigated. When gasoline or distillate is being poured at a high rate into a tank which is insulated from the ground, the flow of the gasoline from the nozzle and the formation of the vapor inside the tank produce static electricity, which charges the vapor and the metallic work of the tank. When a metallic nozzle is used and connected to a pipe which makes contact with the ground on the way from the supply tank, a partial contact between the nozzle and edge of the tank will discharge the tank through the piping, a spark being produced at the same time. If it should happen that the proper mixture of air is existing, ignition is almost certain to take place. The remedy is simple and sure; a ground chain or ground wire should always be put on the tank when it is being filled, and if the nozzle and pipe are not already grounded these should also be connected to the ground.
>
> Static electricity is also produced somewhat similarly in many other instances; for example, a high pressure steam jet exhausting into the atmosphere becomes charged; a cloud of dust suddenly raised takes on an electrical charge and the potential to which it will raise an insulated con-

ductor placed in the dust can be measured. Investigation points to the possibility of some coal-mine explosions having their origin in such a source. Fires in threshing machines also have frequently been caused by the electrification of the smut dust.

This seems to confirm the statements in the letters that have appeared in *Power* on the dates given.

Vancouver, B. C., Canada. R. MANLY ORR.

Power of an Automobile in Unique Instance

In a recent issue of a magazine published by a motor-car manufacturer there appeared an article describing the method used by that company in loading machines on a flat car in order to economize space. A 40-deg. incline was placed on the flat car, and the front wheels of the motor car were run up this incline until the rear wheels nearly reached its base, when the machine was fixed in position. A second incline was placed in a position overlapping the first car, and the second machine was then run up and fixed in place. In this manner, four cars were loaded on one flat which formerly accommodated only two.

In the course of the article reference was made to the power requirements of an engine which could pull a car up a 40-deg. incline, and also to the holding force of the brakes (when the car was at rest) on this incline. Unfortunately, the advertising, rather than the engineering, department of the company is responsible for the article, which doubtless evoked favorable comment by the layman.

The correct analysis of the problem is presented in the following discussion, not so much because of the importance of the problem at hand as to show the value of the graphical method of analysis in many problems of this nature.

In Fig. 1, A represents the rear wheels, moving horizontally with a velocity V_a assumed to be known.

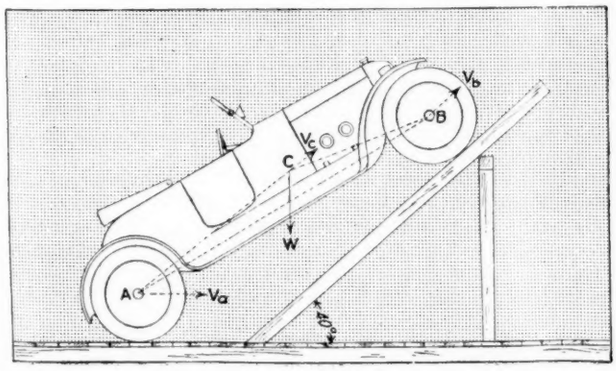


FIG. 1. POSITION OF AUTOMOBILE ON INCLINE

The direction of the velocity V_b of the front wheels B up the incline is known, but its magnitude is as yet unknown. The point C represents the center of gravity of the car.

At any instant the power will be equal to the total weight W multiplied by the vertical component of the velocity of the center of gravity, friction being neglected in this connection. Or the power will be equal to the actual velocity of the center of gravity multiplied by the force that is overcome in the direction of that velocity.

In order to find the velocity of the center of gravity C a polar velocity diagram can be constructed, as shown in Fig. 2. From the pole p the line pa is drawn to represent the known velocity V_a. The line pm is drawn parallel to the direction of the velocity of B. From the point a a line ab is drawn perpendicular to the line AB, in Fig. 1, giving pb as the velocity of the front wheels. The figure abc, Fig. 2, is called the velocity image of ABC, Fig. 1, the point c being located in Fig. 2, so that the figure abc will be similar to ABC, Fig. 1. The line pc is then the velocity of the center

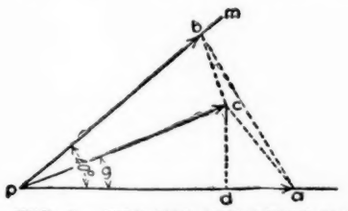


FIG. 2. FINDING VELOCITY OF CENTER OF GRAVITY

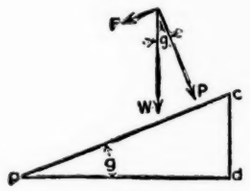


FIG. 3. FINDING FORCES TO BE OVERCOME

of gravity at the given instant, and the angle g will give the equivalent grade up which the car is then pulling.

The power at this instant will be equal to the product of the weight W of the car and the vertical component of the velocity of the center of gravity, or cd, Fig. 2. If, however, the weight W is resolved into two components, F and P, Fig. 3, parallel and perpendicular to the velocity pc, we find, from similar triangles, that $W \times cd = F \times pc =$ the power required at the given instant, considering only the weight of the car.

But the component F is the force that would be required to move the car up the grade g with uniform velocity, neglecting friction, and is therefore the equivalent force at the instant under consideration. When the car is at rest, in the position shown in Fig. 1, the holding force of the brakes would be proportional to F, or the same as though the car were on an actual grade g, and not 40 deg. For the conditions to which this discussion applies the angle g would always be less than 40 degrees.

The average power during the period of lifting the car into place on the incline could be got by plotting several positions, say five or ten, of the center of gravity C, Fig. 1, and the corresponding positions of the point c, Fig. 2, from the time of starting the climb until the end, and taking the average of the products $F \times pc$. Or, more properly, the average power would be equal to the vertical lift of the center of gravity multiplied by the weight and divided by the total time.

Since, therefore, power is proportional to velocity, as well as to the force overcome, the instantaneous power, along with the average, may actually be very small in a case of the kind referred to herein. The result is probably more a demonstration of the holding force of the brakes or the tractive effort of the rear wheels than of power developed by the engine.

The solution of the problem by the strictly algebraic or analytical method would be rather lengthy and tedious, and the advantage of the graphical process is evident.

J. S. A. JOHNSON,

Professor of Applied Mechanics and Experimental Engineering, Virginia Polytechnic Institute.

Blacksburg, Va.

Loss of Power in Waterwheels

During the last twelve years I have observed a considerable loss of power in three different plants where waterwheels were operated in connection with steam engines coupled to the same shaft. These losses were due to the accumulation of trash, such as sticks, leaves and twigs at the racks, also in the buckets or runners of the wheels or turbines. The greatest loss is invariably due to the accumulation in the wheel buckets. Trash in the cylinder gates has caused a very serious loss of power. In one instance one cylinder gate was found broken off and completely closed. The wheel was of the double-flow type and had been running in this condition for some time.

I never fully realized the importance of having the racks cleaned and especially the buckets in the turbine until I had occasion about two years ago to observe the results on a small 150-hp. turbine used to drive a 110-kw. generator for mill lighting. A 75-hp. motor-generator set supplied with purchased power was used to help out the lighting wheel when it lost its power due to the accumulation of trash in the buckets. As the water in the river was very dirty, especially after rains, it was necessary to clean the wheel once each week during the rainy season—in fact it was necessary to clean it after all heavy rains. During the fall of the year, when the leaves started coming down, it was necessary to clean it as often as twice a week.

Of course new racks improved matters, but it was found that it paid to clean the wheels often rather than suffer the loss of power. It had become a custom for the electrician to operate the 75-hp. motor-generator set for 10 to 12 hours a day to help out the lighting wheel whether he really needed it or not. After keeping a record of the cost of this purchased power for three months, it was found that trash in the buckets was costing the company $210 per month, or an average of $8.40 for each working day on a basis of 25 days per month. If the wheel was kept clean, it would pull the load nicely. A similar condition existed in two 350-hp. turbine wheels that operated on the same mill shaft with a 600-hp. cross-compound steam engine, with an additional loss due to trouble with the engine.

After all the experts from the engine company and from other concerns as well had worked on the engine without results, the owners finally took the advice of one of the erecting engineers and employed a first-class engineer. The waterwheels were controlled by a governor with motor-operated speed-changing device, controlled at the throttle in the engine room by a fast and a slow button. The superintendent and master mechanic wanted all the water used possible when the supply was ample, hence the fast button was pressed frequently by the master mechanic, not by the engineer, with the result that the engine governor was working practically out of range and did not control the engine speed. The result was that when the load dropped off, which was quite often, the waterwheels would pull the engine above its no-load speed by 4 to 6 r.p.m. Needless to say the engine gave trouble. It pounded and thumped, and the governors, being of the shaft type, pounded their rims until everybody was afraid to go near the engine. The cylinders also gave trouble because during these periods there was practically no flow of steam through them, hence no cylinder oil could reach the valves and pistons. The rope drive was also a source of considerable trouble as the backlash would cause the ropes to sway and strike each other. A new rope cost nearly $300 and lasted only about a year.

I devised an electrical indicator having ten incandescent lamps. This indicator was located in the engine room and the engineer could always see just how much gate opening there was. Each lamp corresponds with a similar segment on the governor rack so that as the load increases and the piston moves outward to open the gates wider, the contact on the rack closes the circuit on the lamp corresponding with the location of the jointer on rack. The energy for the lamps is supplied by a small transformer at low voltage.

After properly setting the governors and valves on the engine, we were able to secure the maximum benefit from the waterwheels without tearing the engine all to pieces several times each week, thus preventing a great loss due to shutting the mill down as had been done in the past.

After making these changes and then keeping a close touch on the operation, such as to use the water power to the best advantage without being of any great disadvantage to the engine, we were able to produce practically a continuous service and to reduce the coal consumption by three to five tons daily.

This improvement was not secured as easily as it sounds. It required a lot of persuasion, harsh words and ill feelings to get these fellows to break away from their former customs. It had been the habit of the master mechanic to press the fast button without consulting his engineer. In efficiency work, I have found this bucking spirit of the old employees, who are tied to their old customs, the greatest obstacle in securing and maintaining top-notch economy. If the owners and officers of a company will back the efficiency engineer, then he can produce attractive savings, otherwise the old employees who are devoted to their old customs will defeat him at every turn and corner.

Franklin, Ohio. WALDO WEAVER.

Explosions in Pump Discharge Pipe

While I was working in an Arizona mine plant, a slide-valve air pump connected with a barometric condensing system gave a peculiar exhibition one night.

It was about 2 o'clock and things were running along rather quietly. I was standing by one of the windows where I could see the end of the 10-in. discharge pipe from the air pump. Suddenly there was a series of explosions and out of the discharge pipe, apparently at every revolution of the vacuum pump, came a burst of flame. We lost little time in changing over to the stand-by set, and on opening up the air pump it was found that the valve ports were packed and nearly closed with carbonized oil. This choking down of the discharge ports evidently produced enough compression to raise the heat in the cylinder above the flash point of the oil, resulting in the ignition of the gasified lubricant.

After the valve and ports were given a thorough cleaning, the air pump was again in good running order. We have since cleaned it regularly at two-month intervals and have had no further trouble.

Los Angeles, Calif. GEORGE F. SKELLY.

INQUIRIES OF GENERAL INTEREST

Heat Given Off by Room Occupants—In providing for heating of rooms occupied by employees, audiences, etc., what allowance can be made for the number of B.t.u. given off by an average adult? L. R.

The heat given off by an average adult person, sitting in an audience or engaged in desk work, is about 300 B.t.u. per hour, while a moderately active worker gives off about 400 B.t.u. per hour and an average hard worker gives off about 500 B.t.u. per hour.

Exhaust Port Opening of D Slide Valve—If a D slide valve has 6 in. travel, 1½ in. steam lap at each end, ¼ in. exhaust lap, and the eccentric is set for ⅛ in. lead, how much is the exhaust port open when the piston is at the end of its stroke? W. W.

Having 1½ in. lap and ⅛ in. load, the valve would be displaced 1½ + ⅛ = 1⅝ in. to one side of its central position when the piston is at the end of its stroke. The exhaust edge would be moved the same distance, but with ¼ in. exhaust lap the valve would open 1⅝ — ¼ = 1⅜ in. to exhaust, which would be the amount of port opening, provided the port is of sufficient width.

Stack Draft Reduced by Neighboring Hills—When a smoke-stack is situated in a valley where the tops of neighboring hills are higher than the stack, why will not the stack have as good draft as one of the same height placed on top of a hill? A. E. E.

When the wind blows over the crest of a roof or hill, the atmospheric currents to a considerable height above the leeward side follow paths that are downward and nearly parallel with the slope of the roof or hill. From that cause the draft of a stack situated on a hillside, or at the foot of a hill, is retarded by air striking down on the stack, unless it is of sufficient height to extend above the descending air currents.

Equivalent Evaporation—Why is the performance of boilers stated as "equivalent evaporations" or "evaporation from and at 212 deg. F."? W. L. M.

For comparing the evaporative results of boilers operated under different conditions of feed-water temperature and steam pressure, it is necessary to reduce the conditions to a standard. The standard conditions, which have been in use for many years, are those of a feed-water temperature of 212 deg. F. and the evaporation of the water at that temperature into steam at atmospheric pressure, with a temperature of 212 deg. F. This has been called "equivalent evaporation" or "evaporation from and at 212 deg. F." Under the standard conditions each pound of water evaporated into dry saturated steam would require the latent heat of evaporation at atmospheric pressure, or 970.4 B.t.u.

Heating Water with Reduced Pressure of Steam—What saving would there be in boiling water with live steam injected into the water after it is reduced in pressure by means of a reducing valve to 20 lb. per sq.in. instead of using the steam directly from the main line at 100 lb. pressure? J. S. C.

When high-pressure steam is discharged through a reducing valve, the only waste of heat is that lost by radiation just as would be the case with any other type of valve without a reduction of the pressure. Each pound of the steam passed through the valve contains practically the same number of heat units as a pound of the original steam. Although the reduced steam is at lower temperature and pressure, it is less dense, that is, occupies greater volume, and a pound (weight) of the reduced steam would raise the same quantity of water to the same temperature as a pound of the initial steam, provided that temperature is not in excess of the temperature of the reduced steam, and provided also that there is no greater waste of heat in one case than in the other, as by escape of uncondensed steam from the surface of the water that is to be heated.

Choosing Height of Stack—For a plant of 1200 boiler horsepower that is likely to be increased within a few years to 1500 boiler horsepower, would it be more appropriate to build a chimney with 8 ft. diameter of flue, 150 or 200 ft. high? C. F.

The choice between 150 and 200 ft. high would be influenced by the percentage it might be desired to force the boilers, and it may be considered good practice to provide for forcing the boilers at least 50 per cent. beyond rated capacity. The chimney 8 ft. diameter by 150 ft. would permit of forcing 1200 rated boiler horsepower capacity about 55 per cent., but would be suitable for forcing 1500 rated horsepower only about 25 per cent. The chimney 8 ft. by 200 ft., besides giving about 25 per cent. greater force of draft, would have about one-eighth greater capacity, and would permit of forcing 1200 rated boiler horsepower about 75 per cent. and of forcing 1500 boiler horsepower about 40 per cent.

Safety Valve for Compressed-Air Tank—What size of spring-loaded safety valve should be used for a compressed-air tank supplied by a compressor having a rated maximum capacity of 150 cu.ft. of free air per minute, compressed to 100 lb. per sq.in. gage? W. P. A.

The capacity of the safety valve should be 25 per cent. in excess of the rated maximum capacity of the compressor, or 150 × 1.25 = 187.5 cu.ft. per min., and the size of valve may be determined from the formula,

$$Q = 28PDl \text{ or } D = \frac{Q}{28Pl}$$

in which

Q = Discharging capacity of valve, in cubic feet of free air per minute;
D = Diameter of valve in inches;
P = Absolute pressure of air relieved by the valve;
l = Lift of valve, which for standard pop valves may be taken as 1/31 of D.

By substitution the formula becomes

$$D = \frac{187.5}{28 \times (100 + 14.7) \times \frac{D}{31}} \text{ or } D = 1.34 \text{ in.}$$

The nearest commercial size of valve required would be 1½ in. diameter.

Slapping Noise Made by Piston Rings—What causes the slapping or rattling noise of piston rings and how can it be remedied? W. R.

When the noise is confined to the ends of the stroke, the trouble usually comes from the packing ring wiping over the edge of the counterbore. The steam pressure in the counterbored space acting radially on the overhung portion of the ring collapses it into the groove with a slapping or rattling noise. The obvious remedy is to modify the piston to permit of a narrower ring that will wipe nearly flush with the edge of the counterbore, and thus expose little or none of the exterior surface of the ring to steam pressure. Another cause for a slapping noise may be the imperfect fit of the piston ring in its groove. At each end of the stroke, by the reversal of the motion of the piston, and from the steam pressure, the ring is forced by the steam pressure or is dragged by the piston from one side of the groove to the other with a sharp click or hammering noise at the beginning of the stroke, and when the steam pressure is not sufficient to hold the ring against the same side of the groove, the rubbing on the cylinder walls gives rise to a rattling noise during the whole of the stroke. The cure for this is a new ring made wide enough to fit more snugly in the groove.

Storing Coal Successfully*

Fine coal and slack should be stored under water; air currents through the pile should be avoided to prevent spontaneous ignition. The peculiarities of many different coals in storage as experienced by those who store large quantities of coal are set forth.

H. H. STOEK:[1] Although it is true that some coals may be stored with greater safety than others, the danger from spontaneous combustion is due more to improper piling of coal than it is to the kind of coal stored.

Most varieties of bituminous coal can be stored in the air of proper size and if free from fine coal and dust. The coal must be so handled that dust and small coal are not produced in excessive amounts during the storing, because spontaneous combustion is due mainly to the oxidation of the coal surface.

All varieties of bituminous coal can be stored under water which excludes the air and prevents spontaneous combustion.

The danger of spontaneous combustion in storing the coal is greatly reduced if not entirely eliminated by storing only lump coal from which the dust and fine coal have been removed. Of two coals the least friable should be chosen for storage purposes, because less dust and fine coal will be produced in its handling.

Fine coal or slack has sometimes been successfully stored:

a. By preventing air currents through the pile by means of a closely sealed wall built around the pile.

b. By closely packing the fine coal. Such a coal pile must be closely watched for heating. Piles of slack must be very closely watched for heating and means provided for promptly moving the pile if heating develops. The only absolutely safe way to store slack or fine coal is under water.

d. Many varieties of mine-run coal cannot be stored safely because of fine coal and dust mixed with the lumps.

e. Coal exposed to the air for some time may become "seasoned" and thus may be less liable to spontaneous combustion, due to the oxidation of the surface of the lumps of coal, but opinions are by no means unanimous upon this point.

f. It is believed by many that damp coal stored on a damp base is peculiarly liable to spontaneous combustion, but the evidence on this point is by no means conclusive. It is safer not to dampen coal as or after it is placed in storage.

Effect of Sulphur on Spontaneous Combustion

It has been shown by experimentation that the sulphur contained in coal in the form of pyrites is not the chief source of spontaneous combustion, as was formerly supposed, but the oxidation of the sulphur in the coal may assist in breaking up the lumps of coal and thus increase the amount of fine coal, which is particularly liable to rapid oxidation. Even this latter opinion is not unanimously indorsed.

The best preventive of loss in coal storage is to inspect the pile regularly and if heating occurs up to 150 deg. F. to keep close watch on the pile; and if the heating increases to 175 or 180 deg., to remove the coal as promptly as possible from the spot affected, and thoroughly cool it before piling it again.

T. N. WYNNE:[2] The Indianapolis Light and Heat Co. has been storing Indiana coal since 1888. Before 1912 all coal stored was on the ground in open air, with no particular attention paid to sizes, quality or method of storing. In 1912 this company investigated the question of storing coal under water to prevent spontaneous combustion and loss of heating value. No. 4 vein Indiana coal contains approximately 2 per cent. of sulphur and No. 5 vein from 3½ to 6 per cent., and our experience has been that No. 5 will invariably fire if exposed to the air, while No. 4 will not. While we feel it safe to store No. 4 coal on the ground, it is so difficult to obtain that we consider it necessary to provide storage that will be safe for No. 5.

An average of 741 tests shows the freshly mined No. 4 vein coal to contain about 35 per cent. of volatile combustible matter. From tests of various samples taken from No. 4 coal stored for three years in open air at our Kentucky Avenue Station the volatile content was found to average 28.34 per cent., indicating a loss of 20 per cent. This coal during its period of storage did not show any signs of heating.

At the same station we have had stored for about eight months 2000 tons of No. 4 vein Indiana mine-run. This coal has never shown a tendency to fire, although in places it is 35 ft. deep.

The history of coal storage by our company has been a series of fires and losses. In 1912 we constructed at our Mill Street Station a concrete pit 300 ft. long, 100 ft. wide and 20 ft. deep, designed to contain 13,000 tons of coal submerged. A standard-gage track crosses this pit at ground level from one end to the other on concrete piers. The cars are run upon this track and dumped. After the coal has reached a certain height, it must be handled to both sides of the track by means of a hoist. The topography of the ground prevents the elevation of track to facilitate dumping. The pit when filled is not disturbed except in case of shortage in daily delivery. Mine-run coal only is stored because screenings under water become a mud-like mass, almost impossible to handle or burn.

Capillary attraction will take care of coal piled above the water level of the pit as much as 8 or 10 ft., thus permitting of additional capacity of about 40 to 50 per cent.

Whenever coal is taken from the pit to be used on the stokers, it is loaded into railroad cars and the water allowed to drain off for about six hours before the coal is put into the bunkers.

Results of 181 tests of No. 4 vein coal which has been submerged for one year as compared with those of the 741 tests of freshly mined coal previously referred to, show a reduction of 1.7 per cent. in available B.t.u. in the case of the submerged coal. This loss is so small that it might well exist between two lots of freshly mined coal.

Recently, we constructed a reinforced concrete coal pit at our Kentucky Avenue Station, 145 ft. long, 65 ft. wide and 32 ft. deep, built on the same general lines at that at the Mill Street Station and holding 8000 tons.

The Indianapolis Light and Heat Co. burns 500 tons of coal per day, and as the two pits have a total capacity of 20,000 tons of coal submerged and 10,000 tons above the water line, this means a 60 days' supply on hand if both pits are filled. The total cost of the two pits was $60,000 or $2 per ton of storage.

B. J. DENMAN:[3] Up to a few years ago I was in charge of plants burning Pennsylvania and West Virginia coking coals which required storage of approximately 100,000 tons. Mine-run coal was stored in continuous piles as high as could be handled by locomotive cranes. No attempt was made to ventilate the piles, and no fires ever occurred. There was no loss in heating value of coal which had been in storage as much as three years.

I am storing eastern Kentucky "Elkhorn" gas coal for nine gas plants. Most of this is under cover, but some is unprotected. It is stored in piles as high as 25 ft., and no precautions are taken, but no fires have resulted. Most of this coal is ¾-in. lump, but some of it is screenings. Some of the lump has been in storage for five years or more.

For electric plants I am storing each winter in various

*From papers contributed to the Fuel Session, spring meeting, American Society of Mechanical Engineers, Worcester, Mass., June, 1918.

[1]Professor of Mining Engineering, University of Illinois, Urbana, Ill.; Chairman of Fuel Conservation Committee, Fuel Administration of Illinois.

[2]Indianapolis Light and Heat Company, Indianapolis, Ind.

[3]Chief Engineer, Commonwealth Edison Co., Chicago, Ill.

localities from 3000 to 20,000 tons of Illinois and Iowa coal. It is our experience that washed central Illinois coal screenings can be put in stock during the summer and used the following winter with very little danger of firing. Springfield, Ill., district 1¼-in. screenings cannot be put in stock in summer without great danger of firing. If this coal is put in stock during the winter time, when the coal is very cold or mixed with snow, it will ordinarily carry through the following summer. Fulton County, Ill., screenings will ordinarily fire before fall if put in stock during the summer months, although we have one plant in northern Iowa where we put about 3000 tons of this coal in stock each year and have very little trouble; in a number of plants in the central part of the state, however, trouble invariably results. This may be due to some climatic condition, but we cannot account for it.

We have had satisfactory results in storing southern Illinois screenings and experience little trouble. The lump coal from any of the Illinois districts can be carried through the summer without trouble.

Iowa screenings cannot be stored at all during the summer time, and frequently the coal fires in transit. I have had no experience in storing Iowa lump, but am of the opinion that it would disintegrate and fire.

I have had little faith in the usual schemes for ventilating coal piles and have observed several experiments that have not been satisfactory. It is our practice not to store the coal over 12 ft. high, and if it begins to heat to move it quickly.

W. L. ABBOTT:[4] We have stored hundreds of thousands of tons of bituminous coal every year at a cost not to exceed 10c. per ton into and out of storage. We have had no trouble whatever in many years with spontaneous combustion in the coal piles. It has been our experience that we can prevent spontaneous combustion by storing grades of coal that do not contain the small sizes, using preferably a 3-in. by 6-in. egg or lump coal which has gone over a 1½-in. screen.

Fuel Saving in Power Plants

An excellent bulletin entitled "Fuel Saving in Power Plants," has just been issued by the Advisory Engineering Committee to the Massachusetts Fuel Administrator. The committee, which was appointed last May by James J. Storrow, the State Fuel Administrator, consists of Ira N. Hollis, chairman, Charles T. Main, William G. Starkweather, George P. Gilmore, Arthur T. Safford, Joseph A. Skinner and Thomas Hawley. Its specific objects are: (1) The establishment within each industrial plant, or other fuel-consuming plant, of a Fuel and Power Committee, whose duty it shall be to see that fuel is burned economically and to prevent waste of steam and power; (2) to initiate and carry on a campaign of education among fuel and power users; (3) to prepare for distribution among users, engineers and firemen an outline of the various items of loss and to supply information for the purpose of saving fuel and power; (4) to assist local fuel committees in enforcing economies in wasteful plants; (5) to enlist the services of engineers in carrying out this program.

The necessity for a campaign of education against waste lies in the statement of the New England Fuel Administration to the effect that there will be a probable shortage of at least 6,000,000 tons of steam coal in New England in the coming year, and the entire region will suffer unless some measures are taken to reduce the consumption. The bulletin referred to, which is No. 1, forms an important part of the campaign of education. Space limitations prevent the reprinting here of the many valuable suggestions contained in the bulletin, but the following extracts will serve to show the ground covered and the method of attacking the waste problem:

In previous years attention has been directed to the boiler and engine-room equipment as the chief source of loss, but waste is not confined to these departments. The loss or misuse of steam within a mill or factory is just as fatal as the waste of coal in producing that steam. The loss of power in shafting and motors, the waste due to too many lights, are just as fatal to economy. Consequently, savings of coal can be effected only by taking up a manufacturing establishment as a whole, beginning with the unloading of coal from the cars and ending with the shipping of the manufactured product.

Even the best plants have elements of waste and inefficiency which should be examined at this time. There must be no delay, because all methods for reducing coal consumption require preparation and time. Take up the question now in order that coal may be saved for the winter.

The first thing to do in eliminating waste is to organize in each plant a Fuel and Power Committee, composed of employees of the company. This committee should meet once a week to adopt methods for avoiding waste in the following directions:

In the Boiler Room: Stop up cracks and joints in the boiler settings; keep tubes and flues free from soot and do not use scale-producing feed water; keep blowoff and other valves packed and repair leaky joints without delay; avoid blowing down of boilers and blowing of safety valves oftener than necessary; have all steam or hot-water pipes properly covered; return the condensation from heating system and manufacturing processes so as to raise the feed water to the highest possible temperature; employ the best firemen obtainable, as this is the most important element in boiler-room economy; keep the fuel bed even and not too thick (say 6 to 10 in.); watch for thin spots and keep them filled; do not disturb the fuel bed too often; keep ashpit doors closed and regulate draft by dampers; do not let glowing coals accumulate in the ashpit; keep water in the ashpit if possible; keep a record of observations in order to figure the evaporation.

In the Engine Room: Keep a record of engine, turbine and generator performance and power data; watch the atmospheric exhaust head for wasting steam; study the auxiliaries, as these are usually very wasteful of steam and can be allowed only in case their exhaust is used all the time; on reciprocating engines take indicator cards often, reset valves, and examine piston rings to avoid leakage; examine the drip system for leakage of steam by blowing through traps.

In certain plants savings can be effected by turning low-pressure steam back into receivers for use in the low-pressure part of engines and turbines, to produce more power; in others, by the method of bleeding low-pressure steam from the receivers of compound engines or from the later stages of turbines.

It should here be pointed out, however, that the efficiency of any steam engine or turbine (except very large units) does not exceed 20 per cent. in a plant producing power only. But if the steam is first used for power and later for heat, the steam efficiency may approach 100 per cent. Hence see that the utmost use is made of exhaust instead of live steam in heating feed water and buildings and in the manufacturing processes. It is not always appreciated that when exhaust steam is discharged into a condenser there is still a waste of heat in warming up tremendous quantities of cooling water.

In the Manufacturing Processes: Experiment with reduced pressure in drying and other processes to see if exhaust steam may be used instead of live steam. As far as possible provide hot-water supply instead of turning in live steam to warm up cold water. Add automatic temperature control to hot-water heaters, but even with these, shut off the steam at night.

In the Heating of Shops and Workrooms: It is always right to use exhaust steam for heating buildings and water; consequently, time should be taken this summer to modify existing plants in order that exhaust steam may be used. No steam should be allowed to waste through the traps. All windows and doors should be made and kept tight. Stair wells and chutes should be closed off so that cold blasts cannot enter workrooms. Install thermometers and a simple system of reports of temperature. A regular system should be adopted of shutting off heat soon after work is started, instead of opening windows.

In the Lighting System: Shut off every unnecessary lamp and reduce the size of lamps where possible without loss of good service. Modify switching system to give better subdivision so as to light only the parts of rooms being used. Substitute tungsten lamps for carbon lamps.

In the Power Transmission: Determine the amount of friction load, have all bearings and running parts well lubricated; line up shafting and stop every pulley that is not actually in use doing work. Wherever belts can be thrown off, by putting in suspension hooks to support them when not in use a saving is effected. Do not let a motor or engine be operated at a power much below its rated capacity.

[4]Assistant General Manager, United Light and Railways Co., Davenport, Iowa.

Use motor drive instead of small steam engines in remote places where exhaust steam cannot be utilized. Investigate the unnecessary use of power for elevators.

Requests for information and general advice may be referred to the individual members of the committee or to Arthur E. Norton, secretary of the committee, at the office of the State Fuel Administrator, State House, Boston, Mass.

Revision of Pipe-Thread Standards

In January, 1915, the Executive Committee of the American Society for Testing Materials appointed a new technical committee on the revision of pipe threads to consider the advisability of revising the pipe-thread standard with a view of prolonging the life and service of pipes, particularly pipes subject to vibration. At the present time the Briggs Standard thread is used, which is a sharp "V" angular thread. It was also decided to collect data regarding pipe failures and to make tests showing the comparative strength of the Briggs and Whitworth threads. The following societies were asked to coöperate with this committee: American Gas Institute, American Society of Mechanical Engineers, Manufacturers' Association on Standardization of Fittings, Master Car Builders' Association, Railway Signal Association. Various forms of threads were proposed and a number of experiments were made by the committee to determine the strength of the threads, the tightness of the joint, also the practicability of cutting the various forms of threads and of the interchangeability of the suggested types with the existing standard. These experiments have been completed and results of the findings have been duly reported to the Society.

This, of course, is all preliminary, and the most difficult part of the work still lies before the committee. The tremendous manufacturing difficulties involved in any change in standard of pipe threads are fully realized. The type of thread which may be employed is a matter of design, and while it is important to consider the design of thread in relation to the quality of material which is employed in the pipe, it would seem that this matter does not properly fall within the province of the American Society for Testing Materials, the purpose of which is "the promotion of knowledge of materials of engineering and the standardization of specifications and methods for testing," but that the work could more properly be conducted under the auspices of the American Society of Mechanical Engineers—one of the coöperating societies—the object of which society is to "promote the arts and sciences connected with engineering and mechanical construction."

The Council of the American Society of Mechanical Engineers was invited to arrange for the continuation and completion of the work. This action was referred to the American Society of Mechanical Engineers and that society has accepted the responsibility for the continuance of the work.

Unify Power To Save Coal

With a view to saving coal without decreasing power production the United States Fuel Administration has appointed a committee in Illinois on power unification and utilization. The primary purposes of this committee are set forth in the six following objectives:

1. Where two or more electric power plants are located in the same community, whether public utilities or industrial plants, the one or more using the greater amount of coal per given unit of output is to close down and purchase the required energy from the more efficient plant, provided the conservation effected would justify this procedure.

2. To utilize to the greatest possible extent the available water power.

3. To get the coöperation of isolated plants that are not operating efficiently as local electric power plants, by closing down for the period of the war and purchasing the energy needed from the local electric plant when it is in a position to furnish the required energy.

4. The application of the skip-stop to railways and the regulation of car lighting, heating and of car mileage.

5. The interconnection of power systems where savings may be brought about thereby or where additional energy would be available for the community when needed for war industries.

6. By the diversion of power from plants engaged in nonessential war work to plants that are doing essential war work.

A similar plan has been carried out successfully in England, and in Illinois it is expected that considerable coal can be conserved by doing away with needless duplication. It has been estimated by the fuel administration that Illinois will need 95,000,000 tons of fuel this year. The highest weekly maximum so far attained indicates an output of 80,000,000 tons for the twelve months, making a shortage of 15,000,000 tons. Effective work by the committee along the lines mentioned should help to reduce the shortage. The committee is made up as follows: L. E. Myers, chairman, representing the public utilities; Wallace G. Clark, of the Sanitary District, representing state municipalities; Clarence A. Mark, secretary, representing Chicago manufacturers; Fred J. Postel, supervising engineer, department of public works and buildings, representing the state government; Charles H. Ewing, of Decatur, representing manufacturers in the southern part of the state.

Data regarding conditions in the various plants will be obtained from the administrative engineers for the county and the state.

An Ammonia-Saving Suggestion

The Bureau of Standards, of the Department of Commerce, has furnished the United States Food Administration the following statement:

Experimental work carried out at the Bureau of Standards has shown that there are two main causes acting in the formation and accumulation of noncondensing gases in absorption plants, the presence of which necessitates higher working pressures and causes the ammonia losses incident to purging them from the system.

First, air may leak into the system at the aqua ammonia pump, especially when working with low temperatures. This cause may be eliminated by careful packing of the piston rod of the aqua pump, or a drowning box filled with water can be used advantageously to lubricate the rod and prevent the drawing in of air.

Second, hydrogen gas is formed by the action of the water in the system on iron at the temperatures of operation, this action being greatly accelerated by the presence of small quantities of certain impurities, such as carbon dioxide, and increasing with increasing operating temperatures. In purging, if the gas burns on passing through water, the second is the main cause operating and the gas formation owing to this cause can be inhibited by the addition of sodium-bichromate solution. The amount of sodium bichromate added should be about 0.2 per cent. by weight (1-5 lb. for each 100 lb.) of the total aqua ammonia charge. It is only necessary to dissolve it in a small quantity of water and add at the aqua ammonia pump while the plant is operating. A second charge of equal strength may be necessary after a time. This material may be obtained from any of the chemical supply houses at from 40 to 50c. per pound, also from manufacturers of absorption refrigerating machinery. For a 30-ton plant the cost of treatment will be about one dollar.

A group of Belgian manufacturers and business men has been selected to form an organization with the object of helping the industrial reconstruction of the country after the war with the aid of and under government control and supervision under the name of National Bureau of Resumption of Economical Activities in Belgium (Société Coöperative), Liége Social, 15 Rue Louis le Grand (11e). This organization will enable the Belgian industries to replenish themselves in the shortest time possible after the war.

Practically everything is to be rebuilt. Materials of construction, leathers, textiles, farming tools, chemical products, woodworking machines, electric appliances, precision tools, instruments, motor trucks, sea and canal transports, oils, grease of all description, refractories, etc., will be needed. The French industry is invited to state under what conditions and how much of both raw material and finished products they could eventually supply. All those willing to contribute are asked to send, without delay, three copies of their catalogs, with specifications and prices.

Dry and Wet Coal as Fired in a Low-Pressure Steam-Heating Boiler

The effect upon the efficiency of a boiler when using wet and dry coal has not been definitely known, according to J. J. Light, instructor in mechanical engineering, in Bulletin No. 22 of the Engineering Experiment Station of the Pennsylvania State College. Among coal users, especially those operating house-heating boilers, there is a wide difference of opinion as to the relative merits of the practice of wetting the coal before firing. The object of a series of 10 tests tabulated was to show the efficiency of a house-heating plant when fired with coal that has been made wet, and with coal as usually found in cellars of residences, which can be considered as practically dry.

Since two series of tests were run under the same conditions except for moisture of the coal, it is possible to obtain information as to the benefits derived in house heating by firing either dry or wet coal. The conclusion is that the common inference that an addition of water to the coal as fired is beneficial to the operation of the furnace seems false.

The tests from which the results were obtained were in charge of an experienced fireman, who had very strong convictions, from his practical experience, that moistening the coal was a decided commercial advantage in the operation of boiler plants, which fact would in all probability produce an error in favor of wet coal provided any error was introduced.

The item, equivalent evaporation from and at 212 deg. F. per pound of combustible, and the item, efficiency of the furnace, are two factors which would appear to decide the relative merits of the wet and dry coal. It developed throughout the tests that one pound of combustible evaporates more when the coal is fired dry or as is ordinarily found in cellars of residences than when it is purposely moistened. The efficiency of the furnace throughout the tests showed that wet coal tends to decrease rather than increase operating economy.

From a theoretical point of view the addition of water to the coal is a decided loss and would probably be equal to the heat required to evaporate the water added, from the room temperature into steam at a temperature corresponding to the flue gas under the pressure as maintained in the flue. It is the opinion of those who are believers in moistening the coal that the addition of water aids in the complete combustion of the volatile hydrocarbons. This fact probably cannot be disputed, but the tests showed that the gain due to complete combustion is less than the heat carried away by the water. The small differences in efficiencies would, however, hardly be noticeable to most people, and it is quite natural to think that wet coal would give the best results for the reason that coal being wet when placed upon the fire produces slower combustion. This would give better conditions for the combustion of the volatile and other hydrocarbons, but the tests seem to indicate as well as theory that the heat required to burn the wet coal is greater than the heat lost by firing the dry coal.

War Department Centralizes Purchasing Control

Organization of the centralized purchasing scheme whereby the General Staff controls the buying of all commodities and supervises all contracts for the Army is rapidly progressing. Already assignment of purchases of a number of commodities has been made to the several branches of the War Department, and boards of review are passing on all contracts in order to insure uniformity of contract control and provisions. The general administration of the scheme is under the direction of Brig. Gen. Hugh S. Johnson, head of the purchase and supply branch of the division of purchase, storage and traffic of the General Staff of the Army.

In the past the various branches of the department have been buying their respective commodities through their own purchasing agencies, often bidding against one another for the same goods and frequently paying several different prices for the same article. The General Staff brought together a committee of representatives of the various purchasing agencies, and this committee is now engaged in standardizing the commodities needed and assigning to one branch of the department the purchase of each commodity. The following paragraphs give the names of the branches intrusted with the purchase of about 150 items so far agreed upon. Others are being added to the list each day.

Quartermaster—Automobile drive chain, iceboxes, burlap, nonskid chains, cotton cloth, cotton goods, cotton rope, silk fabric, rubber goods, woolen rubber goods, jutes, leather, linen, manila rope, needles, woolen goods.

Construction—Reinforcing bars, cement, clay products, electrical equipment and supplies, electric wire for heavy power refrigerating equipment, sand and gravel, rough hardware, heaters, room heating equipment and supplies, plumbing equipment and supplies, roofing material, sprinkler systems, ventilating equipment, water supply equipment and fixtures, structural steel.

Ordnance—Chrome and ferromanganese alloys, ammonium nitrate, artillery chain, barometers, dry batteries, blast furnace and steel mill products, cartridge cloth, coal gas products, coal tar products, cotton linters, forging equipment, hull fiber, flashlights, dry-cell lanterns, nitrates, tin, pig tin, plate tin, platinum, sodium nitrate, stop watches.

Engineers—Arc searchlights, chain, paint containers, gantry cranes, locomotive cranes, paint driers, electric gas generator sets, enamels, gas engines, mechanical rubber goods, japans, lacquers, mineral spirits, paint, steam shovels, turpentine, varnishes, linseed oil, railway equipment.

Signal—Electric wire, radio equipment, telephone and telegraph equipment.

Aircraft Production—Aeroplane cloth, brass and copper tubing, electric wire and cable, clocks, aviators' clothing, compasses, wood distillates, gages—oil, air and gasoline; steel hangars, linen fabric for balloons and aircraft, thermometers, spar varnish.

Medical—Surgical dressings, surgical needles, medical thermometers.

Chemical and War Gas—Elastic tape, horse masks.

A further extension of purchasing is the establishment of boards of review which have to pass on all contracts before they become valid. Boards of review have been established in each of the eight purchasing bureaus; that is, quartermaster, construction, ordnance, engineers, signal, aircraft production, medical and chemical and war gas. Each board consists of men representing purchasing, finance, production and contracts. This board passes first on all contracts more than $5000, second on all cost-plus contracts and third on all formal competitive bidding contracts where the contract is not awarded to lowest bidder by the local officer. It sits every day and goes over each contract—those from remote points by telegraph if necessary—and approves only those which are in accordance with the rules laid down by the main committee on purchases or which seem to be at prices in accordance with the state of the market.

In addition to these departmental boards there is a superior board of review, consisting of General Johnson, a representative of each minor board and Max Thelen, who is surveyor of contracts. This superior board passes on large questions of purchase and contract, lays down the general rules of purchase and acts as a court of appeal from the lower boards. In general, any dissatisfied prospective contractor has the right of appeal to the superior board.

Signal Corps Wants Men for Photographic Work

The Signal Corps announces an urgent need for a large number of men to engage in the compilation of a pictorial history of the war. About 60 more lieutenants and as many sergeants, first class, are to be selected for this work; and for a short time, until the immediate needs are met, some commissions will be given to men direct from civil life whose experience is ample to justify this procedure. Other men will be sent temporarily to the Signal Corps School of Photography at Columbia University, New York City, where they will be taught, not how to take pictures, but rather what kind of pictures to take. Many of the men commis-

sioned will become staff officers of army divisions and as such will be in charge of the work of making a pictorial history of the activities of that division from the time of its organization through its active war service.

The Signal Corps states that appointment will depend almost entirely on a man's previous experience. Application for service can be made and full particulars obtained by addressing the Office of the Chief Signal Officer, Photographic Section, Arcade Building, Washington.

Joseph Harrington Administrative Engineer for Illinois

The Fuel Administration has just announced the appointment of Joseph Harrington, vice president of the James A. Brady Foundry Co., Chicago, as the administrative engineer for the State of Illinois. Mr. Harrington's plans are not completed as yet, but it is expected that he will put into effect many of the policies that have been tried and found successful in other states for similar purposes. The entire power-plant field will be thoroughly canvassed. Questionnaires will be sent to every power plant in the state and the inspection service will shortly follow up with a personal inspection. In addition to the rather well-defined plans for high-pressure steam plants, the conservation committee for the state will also have its headquarters in Mr. Harrington's office, and such things as curtailment of street lighting, illuminating signs in connection with power plants, the reduction in fuel supply to nonessential industries, etc., will be handled there. The recent order also provides that the purchase of any new power-plant equipment must first receive the approval of the administrative engineer. One of the difficulties that the administrative engineer has already encountered is the absence of a comprehensive list of power plants. It was found upon going into this matter that even the better classes of power plants were unlisted, and that one of the first and most important duties of this office will be to secure such lists. These are, for illustration, storage warehouses, high-pressure apartment heating plants, laundries, public buildings, etc.

Invitations have been issued by Mr. Harrington to approximately two hundred consulting engineers in the state, asking certain questions to bring out their availability as advisers to power-plant owners and managers throughout the state. The primary purpose of this office is not to perform a consulting service; and in those instances where it is advisable, a list of consulting engineers familiar with this work will be handed to the owner, who will select therefrom one to do his work as a paid employee.

Lumber Exchange Building, Chicago, Buys Summer Current

One of the first conservation plants, as they are called, in Chicago is the Lumber Exchange Building, owned by the L. J. McCormick Estate. On July 29 a contract was signed with the Commonwealth Edison Co. for summer current. As early as May of this year, M. T. Kimman, chief engineer for the estate, realized the possibilities and began negotiations with the central station. Shortage of good firemen, labor troubles with watch engineers and subsequent urging by Harold Almert, administrative engineer of the Fuel Administration for Cook County, had their effect, so that the change was eventually made and fuel will be conserved for half the four-month period during which a saving would be possible. Promptly on Oct. 1, when steam will be needed for heating, the service will be shifted back to the building plant and the term "conservation" will be still more appropriate, as the saving for the eight months succeeding will be far greater than for the reverse arrangement during the summer.

Reference to the June 8, 1915, issue of *Power*, in which the plant was described, will show an ideal installation for the present change. The building is a 20-story L-shaped structure situated on a corner with a street frontage of 101 and 135 ft. The plant contains four 200-hp. Scotch marine boilers of the dry-back type, stoker-fired; two poppet four-valve engine-driven generators of 300 and 200 kw. capacity and a 100-kw. turbo-generator. The five passenger elevators of the 1 to 1 gearless traction type serving the building, the freight elevator, a 4000-lb. hydraulic lift for service between the main floor and the basement, all ventilating fans and the pumps, with the exception of those feeding the boilers, are electrically driven. Heating service water for the building is the only use for exhaust steam during the summer months. These are the features that made the change so easy. Hydraulic elevators served by steam pumps would have introduced a different problem.

Plant records for June of the present year show a kilowatt-hour production of 48,889. The coal consumption was 195.5 tons, which, when charging all coal to electric production, reduces to approximately 8 lb. per kilowatt-hour. On a basis of 2 lb. per kilowatt-hour, which is perhaps rather low for an average figure including all losses, the central station is expected to produce the same electrical output on 49 tons of coal. About 15 tons of coal will be required to heat the service water, so that the monthly saving in coal during the summer should approximate 162 tons. For the two months during which the service will be maintained there will be a total saving to the community of 324 tons of coal, and if the service had been installed June 1, the saving would have been doubled. The saving, however, is more apparent than real. This plant and most of the other office-building plants in the loop burn screenings, a byproduct of domestic coal which cannot be stored and of which there is now and always has been an excess supply. The central station, on the other hand, uses largely run-of-mine coal and crushes it at the plant.

It is evident that there is a field for coöperation between private plants and the central station and especially where the use for exhaust steam during the summer reduces to such a low ebb as in the present case. During eight months of the year the central station cannot legitimately compete, but during the summer coal may be saved in some cases by taking service. As previously stated, this depends on the uses for exhaust steam and the steam-using machinery in the plant other than that for electric generation. Each plant is in itself a distinct problem, which, for patriotic as well as selfish interests, should be investigated. If a saving in coal may be effected by purchasing current, the thing to do is to coöperate. It is important, however, to retain the operating force and keep the plant intact, as for the same reasons they will be needed in the fall.

Private plant engineers are wondering how the proposed superpower station scheme will affect them, according to the *Power User*, London. We consider that the engineer who is worth his salt has nothing to fear. The recorded costs of public supply stations show that the small station has often held pride of place for economical generating costs. Prescot, in Lancashire, for instance, has many times beaten the largest plants in the country for low costs, though its plant is of small capacity and not of the most modern type. We can call to mind without effort three separate colliery plants generating their own electric power by means of coke-oven and blast-furnace gas engine sets at so low a cost per unit that no outside authority could supply at the price without incurring a heavy loss; yet the sets are only of 500-kw. capacity and the total yearly output insignificant from the point of view of the superstation, but the reliability of supply over a long period has proved to be very high. The first textile mill to be run from a public electricity supply, after ten years' experience of purchased power, put down its own power station to drive a new mill erected in the same district. As long as the private-plant engineer maintains his plant efficiency, he need not worry about his future position.

If the fillets of a crankpin are touched by the ends of the brasses when cold, when they warm up they will expand onto the fillets, lifting or tending to lift the brasses from the pin, thus resulting in cutting or heating, and you have trouble. See that there is a good clearance between fillets and brasses. A little too much is better than not quite enough.—*Marine Engineering.*

Self-Adjusting Spring Thrust Bearing*

By H. G. REIST

A novel form of bearing consisting of a cast-iron runner resting on a babbitted stationary ring is supported by a large number of short helical springs and prevented from turning by dowel pins.

IN ORDER to maintain a film of oil of fairly uniform thickness in bearings of the constructions now in use, it is necessary that the parts which form the bearing surface shall be exceedingly rigid so that the deflection of the bearing surface shall be very small. With this precaution and with very accurate fitting it is theoretically possible to maintain over the whole surface of the bearing, or a large area thereof, a film of oil sufficiently thin to support a fair pressure per inch of bearing. It is for this reason that the shells of ordinary bearings are made quite stiff so that they will do some supporting even at the ends. The ideal condition would be to have the deflection of the bearing and shaft the same but in practice this cannot be accomplished.

The bearing that is to be described departs altogether from these principles and is based on the idea of a bearing surface which is so yielding, flexible and elastic that it may follow the irregularities of the rotating surface without creating at any point a pressure per square inch sufficient to destroy the oil film.

Thrust-bearing surfaces are usually scraped to each other, or to a surface plate, to avoid dangerously high spots; but since the oil film is of the order of 0.0002 in. to 0.0003 in. in thickness, the difference in level must be smaller than these values. This work must usually be done without load, and, no matter how carefully done, when the bearing is loaded the parts will probably not fit each other, owing to deflection.

A careful study of the difficulties mentioned led to the design of a flexible bearing surface pressed against the runner by springs. A typical design of a spring-thrust bearing for vertical-shaft machines is shown in Fig. 1. The bearing consists of a runner of a special grade of cast iron resting on a thin steel ring with a babbitted surface. The babbitted stationary ring, in turn, rests on short helical springs and is held against rotation by dowel pins. A saw cut through one side eliminates any tendency of the ring to dish with a change in temperature. The high base ring shown, on which the springs stand, is often used in connection with a deep housing to increase the amount of oil in the surrounding bath. The tube in the center forms a retaining wall around the shaft, for the oil. The springs ordinarily used are wound of ½-in. round wire and have an outside diameter of 2 in. and a free length of 1½ in. Under load the springs close about 1-16 in., and the total pressure is well distributed. By this means it is possible to avoid excessive pressures at any point. Thus it is safe to run with a much higher average pressure than when there is no definite limit to the pressure which may occur over a small area.

Oil grooves are provided in one of the members and sometimes in both. In order to insure proper circulation of the oil for cooling purposes, in the case of bearings operating at low speed it is necessary to have grooves in the rotor. On high speeds these grooves may sometimes be omitted, relying for circulation only on the friction of the rotor on the oil while passing the grooves in the stator. In many cases we have had very satisfactory results by placing radial grooves in both the rotating and the stationary surface. It is our practice to have different numbers of grooves in the two plates, for instance, six and eight. With grooves in each of the surfaces we have a continuous flooding of oil on all the bearing surfaces and a very effective means of cooling. Much of the heat would otherwise have to be transmitted through the metal of the stationary part of the bearing.

The pressure usually allowed on these bearings is from 300 to 400 lb. per sq.in., the design permitting a very thin oil film without metallic contact. It is necessary to have the runner very smooth and free from scratches, especially any at an angle to the direction of rotation, as these might cause injury to the babbitt. The babbitted surface does not need to be scraped, but is turned with a tool as smooth as is convenient.

It is desirable to run bearings at a high pressure if they can be designed to do this safely, as the parts then are smaller, the rubbing speed is less, and the friction very much reduced. With this design of bearing the tendency to excessive pressure at one point is automatically relieved by the springs yielding, and while there will be some uneven distribution, a variation in pressure of two or three times the average is comparatively unimportant and does not cause bearing failures; it is pressures of twenty or more times the average that cause injury. These excessive pressures are prevented by the construction just described. For this reason it is safer to operate this bearing with high pressures than a more rigid bearing at lower pressures.

FIG. 1. BEARING TO CARRY A LOAD OF 300,000 LB. AT 100 R.P.M.

FIG. 2. BEARING FOR MACHINES WITH SMALL CLEARANCES

An advantage of increased pressure in the reduction of friction is shown by the following table of comparison:

Bearing number	1	2
Revolutions per min.	200	200
Total load, lb.	300,000	300,000
Outside diameter of bearing, in.	35	46
Inside diameter of bearing, in.	17.5	17.5
Net area, sq.in.	600	1200
Pressure, lb. per sq.in.	500	250
Average rubbing speed, ft. per min.	1370	1670
Coefficient of friction	0.0018	0.0033
Kilowatt loss	16.7	38
Horsepower loss	22.5	51

In some designs the vertical clearance between the waterwheel and the casing is very small, so that the displacement caused by a free spring under the variation of hydraulic suction is objectionable. In such cases an initial compression equal to full load, or to an overload, is put on the springs. The load will still distribute, since an overload at any point will cause the spring to close beyond the initial compression. Such a bearing is shown in Fig. 2. However, this was designed to replace a roller bearing, and was so made that the parts of the waterwheel would occupy the same relative positions as before. The principles used in the construction of these thrust bearings are applicable also to journal bearings and to bearing surfaces having a reciprocating motion, like the crosshead of a steam or gas engine.

*Excerpts from a paper presented at the Worcester meeting of the American Society of Mechanical Engineers.

Surplus electric power produced by the Stimson Mill Co. at Ballard, Wash., by the burning of waste material will be sold to the City of Seattle at 0.004c. per kilowatt-hour.

Specifications for White Bearing Metal

The composition of white bearing metal (babbitt metal) as recommended by the American Society for Testing Materials, Philadelphia, Penn., is as follows: These tentative specifications were presented before the society during its recent convention at Atlantic City, N. J.

The alloys shall conform to the following requirements as to chemical composition, within the limits specified below.

TABLE I. COMPOSITION OF WHITE BEARING METAL

Alloy, Grade No.	Tin, per Cent.	Antimony, per Cent.	Lead, per Cent.	Copper, per Cent.	Iron Max., per Cent.	Arsenic, Max., per Cent.	Zinc, per Cent.	Aluminum per Cent.
1	91	4½	0.35*	4½	0.08	0.10	None	None
2	89	7½	0.35*	3½	0.08	0.10	None	None
3	83⅓	8⅓	0.35*	8⅓	0.08	0.10	None	None
4	75	12	10	3	0.08	0.15	None	None
5	65	15	18	2	0.08	0.15	None	None
6	20	15	63½	1½	0.08	0.15	None	None
7	10	15	75	0.50*	....	0.20	None	None
8	5	15	80	0.50*	....	0.20	None	None
9	5	10	85	0.50*	....	0.20	None	None
10	2	15	83	0.50*	....	0.20	None	None
11	..	15	85	0.50*	....	0.25	None	None
12	..	10	90	0.50*	....	0.25	None	None

* Maximum.

The following permissible variations in the percentages of the desired elements specified above will be allowed, but shall not apply to the maximum percentages of impurities specified:

Percentage of Element Specified	Permissible Variations Over or Under the Specified Value, Units of per Cent.
Not over 2 per cent	0.25
Over 2 to 5 per cent, incl	0.50
Over 5 to 10 per cent., incl	0.75
Over 10 per cent	1.00

Table II gives the physical properties of these grades of alloy; the table is not a part of the specifications, being given merely as information.

TABLE II. SHOWING PHYSICAL PROPERTIES OF WHITE METAL BEARING ALLOYS

Alloy No.	Formula Copper, per Cent.	Tin, per Cent.	Antimony, per Cent.	Lead, per Cent.	Deformation of Cylinder 1¼ in. Diam. by 2½ in. High at 70 Deg. F., In. At 1,000 Lb.	At 5,000 Lb.	At 10,000 Lb.	Brinell Hardness At 70° F.	At 212° F.	Melting Point Deg. F.	Deg. C.	Complete Liquation Point Deg. F.	Deg. C.	Specific Gravity	Weight Oz. per Cu.In.	Grams per Cu.In.	Proper Pouring Temperature Deg. F.
1	4.5	91.0	4.5	....	0.000	0.001	0.015	28.6	12.8	453.2	234	699.8	371	7.34	4.24	120.28	824
2	3.5	89.0	7.5	....	0.0000	0.0015	0.0120	28.3	12.7	460.4	238	683.6	362	7.39	4.27	121.10	808
3	8.33⅓	83.33⅓	8.33⅓	....	0.0010	0.0045	0.0070	34.4	15.7	462.2	239	791.6	422	7.46	4.31	122.25	916
4	3.0	75.0	12.0	10.0	0.0005	0.0025	0.0090	29.6	12.8	365.0	185	555.8	291	7.52	4.35	123.23	680
5	2.0	65.0	15.0	18.0	0.0010	0.0030	0.0090	29.6	11.8	.....	...	.....	...	7.75	4.48	127.00	...
6	1.5	20.0	15.0	63.5	0.0015	0.0050	0.0180	24.3	11.1	.....	...	.....	...	9.33	5.39	152.89	...
7	...	10.0	15.0	75.0	0.0010	0.0050	0.0230	24.1	11.7	464.0	240	500.0	260	9.73	5.62	159.44	625
8	...	5.0	15.0	80.0	0.0020	0.0090	0.0620	20.9	10.3	469.4	243	500.0	260	10.04	5.80	164.52	625
9	...	5.0	10.0	85.0	0.0040	0.0120	0.0840	19.5	8.6	469.4	243	491.0	255	10.24	5.92	167.80	616
10	...	2.0	15.0	83.0	0.0010	0.0100	0.1540	17.0	8.9	471.2	244	500.0	260	10.07	5.82	165.02	625
11	...	.....	15.0	85.0	0.0010	0.0100	0.1190	17.0	9.9	474.8	246	500.0	260	10.28	5.94	168.46	625
12	...	.....	10.0	90.0	0.0025	0.0170	0.2850	14.3	6.4	474.8	246	509.0	265	10.67	6.17	174.85	634

Production of Asbestos Increasing

The total quantity of domestic asbestos sold in 1917, according to J. S. Diller, of the United States Geological Survey, Department of the Interior, was 1683 short tons, valued at $506,583, an increase of about 13 per cent. in both quantity and value over 1916. Most of the domestic asbestos comes from Arizona, where the proportion of crude spinning fiber to that of lower grades is much larger than in Canada, so that the average price of American fiber in 1917 was $301 a ton, whereas the average price of that in Canada was only about $50.

Some years ago the opinion was expressed that as the Arizona fiber contains less iron than that mined in Canada, it is therefore better adapted to use for electrical insulation than the Canadian fiber. This opinion has lately been confirmed by analyses made by R. E. Zimmerman, of Pittsburgh, whose investigations also indicate that the harshness of certain parts of the Arizona asbestos is due to thin films of calcite among the fibers. A small amount of spinning fiber was mined in Fremont County, Wyoming, from a contact deposit of remarkable interest. The increased demands for asbestos due to the war have been met largely by increased imports from Canada. The imports of asbestos from South Africa and Italy have been largely cut off. The demand for imported asbestos for use in filters is being supplied by amphibole asbestos obtained from residual deposits of the crystalline rocks of Maryland.

Engineering Applied to Packing Cases

Men of expert engineering skill employed to work out new ideas in mechanical efficiency in up-to-date American manufacturing plants are now devoting attention with very good results to the designing of the best economical packing cases for the special products of several leading corporations. The fact is becoming generally recognized that for all practical intents and purposes of business, certain kinds of special merchandise are not completely manufactured until they are properly packed for shipment. A manufacturer's net return for a vacuum cleaner, a gross of incandescent electric lamps, a 50-lb. lot of calcium carbide or a gross of bottled perfumes is what he receives for it safely delivered to his customer, which means that it must be packed securely and his price to his customer almost always includes the container. In large-scale manufacture and distribution, it works out that the cost of a well-designed packing for the product is an important element in cost of manufacture.

In America's leading petroleum refineries there is included a mechanical packing establishment, scientifically designed and constructed for the purpose. Rough lumber in standard sizes is fed into machinery at one side of this packing shed. Ready-made tin containers are put upon mechanical conveyors at another place. Without a touch of a man's hands, except on controlling devices, the cans are carried to a machine that fills them with oil, the boards are cut to pieces of just the right size, the cans and boards meet and, wholly by machine, the wooden crate is built around the can; then the filled package is mechanically conveyed along to the hold of a ship or to a storage dock. The tin container, the lumber, the nails, the packing machinery, all were the subject of careful engineering design, for the purpose of obtaining strength, stability, lightness, and at a minimum cost.—*The Americas.*

The shipyards of America established an unparalleled record during July, launching 631,944 deadweight tons. The number of ships launched was 123, divided as follows: Sixty-seven steel vessels, 433,244 tons; 53 wooden vessels, 187,700 tons, and 3 composite vessels, 11,000 tons. The total tonnage of ships launched this year is now 1,719,536.

In the year since the Shipping Board assumed control a grand total of 247 ships, aggregating 1,571,856 deadweight tons, has been completed and placed in service, almost half of it being delivered during the last three months.

A likeable personality is a passport, good for life and in all countries. Tact and diplomacy solve more problems than engineering formulas. A memory for names and faces will help you more than one for minerals and rocks. Good sense, that ability to decide which of any two things is the more important, is an asset beyond price.—*Kirby in the Sibley Journal.*

New Publications

PRINCIPLES OF MECHANISM. By Walter H. James and M. C. Mackenzie. Published by John Wiley & Sons, Inc., New York, 1918. Cloth, 5 x 7½ in.; 241 pages; 108 illustrations. Price, $1.50.

This volume is intended to present the elementary principles of mechanism in a way that will make it adapted for use in evening technical schools, trade schools, mechanical high and other schools where it is desired to teach the subject without going into the highly mathematical treatment. Typical problems are solved throughout the text matter, and a number of problems are included for solution by the student. Probably the chapter on belts, ropes and cams would interest the engineer more than any other, inasmuch as various methods of running belts and the matter of figuring the speed of shafting with different diameter of pulleys, when belt-driven, are dealt with. Various rules for finding the horsepower of a belt are also given, and accompanying examples will assist the students in working out the rules correctly. Although such problems may have been familiar at one time or another, they are easily forgotten, as, for instance, the formula for calculating the length of belt, how to proportion the diameter of stepped pulleys for both open and cross belts, speed cones, how to arrange belt connections between shafts that are not parallel and how to arrange for quarter-turn belts. These subjects, as is also that of rope drive, are treated in this volume. The chapters on gearing and cams, wheel trains and link and linkage should be of interest and of value to the engineer.

CIRCULAR OF THE BUREAU OF STANDARDS, No. 72, Washington, D. C. Paper, 7 x 10 in.; 84 pages. Price, 20c.

This circular relates to the scope and application of the National Electric Safety Code, which is a set of rules that have been prepared by the Bureau of Standards after several years of study and investigation. It is intended to furnish a guide for safe electrical practice and is concerned with both electrical construction and operation. The code deals with the generation, distribution and use of electricity, and is subdivided, for convenience, into four principal parts. The circular explains the need for such a code and gives examples of personal injury by electricity which show the many types of accidents occurring, most of which could be avoided by observance of the rules. Sections 1 and 2 are devoted to this part of the publication. The second part gives reasons for the arangements of the code in its present form and explains by means of discussions and examples the intended method of use of the code by engineers and inspectors. This is taken up in Sections 3 to 5. The third part provides a short summary of the provisions of the code for those who wish a general or bird's-eye view of the provisions. Sections 6 to 10 are devoted to this. Part 4 has a special value for those applying the code, such as electrical contractors, utility engineers, managers and foremen, factory electricians and all classes of inspectors. Section 5 will be useful mainly to inspectors, and the remaining sections, summarizing the separate parts of the code, will be useful to any of the foregoing classes of readers or others who desire a knowledge of the general scope of these parts without going over the text of the individual rules.

BOOKKEEPING AND COST ACCOUNTING FOR FACTORIES. By William Kent. Published by John Wiley and Sons, Inc., New York. Cloth, 261 pages; 8½ x 11 in.; 16 illustrations and numerous tables and blank forms. Price, $4.

The large number of books that have been published during recent years on cost accounting forms sufficient evidence of the interest in that subject. Yet when Mr. Kent began a serious and exhaustive study of them, he found not only a lack of uniformity but a condition practically chaotic. In the belief that the time is ripe for a systematic treatise on cost accounting, he has collected the results of his study and has produced the present treatise. In order to lay a stable foundation for his treatment of the subject, he has begun with the elementary principles of double-entry bookkeeping, passing then to factory accounting and finally to cost accounting. He has given the fundamental theory in accordance with the views of the ablest modern accountants and at the same time pointed out the fallacies and errors of the older ones. The introductory chapters, together with those explaining factory accounting and methods of cost accounting, comprise about half of the book, the remainder being given over to practical cost accounting in such widely different lines as a blast furnace, a steel works, foundries, a hardware factory, a machine shop, a bakery, a textile mill, a wood-working shop, power plants and printing shops. In the preparation of the material for this book, the author made personal study of the cost-accounting systems in use in a number of large manufacturing establishments and consulted with accountants and officers of corporations. One of the features of the book is the use of a great number of blank forms such as are employed in keeping records for the purpose of determining costs. The concluding chapter deals with reports to stockholders and a bibliography of works on cost accounting and scientific management is appended.

IRON, STEEL AND NONFERROUS PRODUCTS

A booklet giving the complete schedules of maximum base prices now in effect on iron, steel and nonferrous products as fixed by the Government, has been issued by the *Iron Trade Review*, of Cleveland, Ohio. The pamphlet, which contains 75 pages, 6 x 8¼ in., with index, is an up-to-date manual on iron and steel prices, giving a complete list of base prices, differentials and extras on iron, steel and nonferrous products, fixed direct by the Government and through recommendation of the American Iron and Steel Institute. The price of the booklet is $1.

Personals

C. Edwin Clarke, formerly chief engineer of the Wilmington (Del.) Steel Co., is now master mechanic of the Saucon plant of the Bethlehem (Penn.) Steel Co.

Arthur Seubert, formerly instructor in mechanical engineering at Polytechnic Institute, Brooklyn, is now assistant mechanical engineer of the New York Edison Co., New York City.

Joseph H. Cheetham, formerly chief mechanical engineer of McNab & Harlin Manufacturing Co., Paterson, N. J., is now superintendent of the Kunkle Valve Co., Fort Wayne, Ind

W. Herman Gruel, who was connected with the Otis Elevator Co., New York City, for several years, was recently elected president of the Standard Plunger Elevator Co., Worcester, Mass.

Joseph Harrington has recently been elected vice president and general manager of the James A. Brady Foundry Co., Chicago, having charge of the department of engineering and construction.

F. W. Laas, formerly chief engineer of the Iowa Railway and Light Co., Iowa Electric Co. and Iowa Falls Electric Co., of Cedar Rapids, resigned to become superintendent of power for the Western Light and Power Co., Boulder, Colo.

John I. Cranford, for the last eight years chief engineer in charge of the Oxyacetylene and thermit welding and fire apparatus for the Spanish-American Iron Co., at Felton, Cuba, has resigned to return to the United States, where he will follow the same line of business.

Miscellaneous News

The Present Average Price for electricity supplied by the municipal plant of Leeds, England, is 2.2c per unit, an increase of about 20 per cent. upon the pre-war charge, but still substantially below the average charge of other municipalities.

Trade Catalogs

The Green Engineering Co., of East Chicago, Ind., has just issued a booklet entitled "Capacity." It illustrates and describes the efficiency and economy of using Sealflex arches in boiler furnaces. A copy may be had upon application.

The Steel City Electric Co., Pittsburgh, Penn., has issued its new catalog No. 33. Pages 108, 6 x 9 in. This catalog cancels and supersedes previous bulletins and shows a complete line of the company's products. A free copy may be had upon application.

New Construction

Mass., Charlestown—The Boston and Maine R. R., Boston, is in the market for power piping, pumps, blowers, galvanized iron blower system, etc., in connection with the proposed 1 story roundhouse to be erected here.

Mass., Deerfield—The Boston and Maine R. R., Boston, is in the market for power piping, pumps, blowers, etc., in connection with the proposed 1 story, 90 x 200 ft. roundhouse to be erected at East Deerfield.

Conn., Hartford—H. Evarts, 14 Forest St., is in the market for shafting, motors, etc., in connection with the proposed 1-story, 40 x 114 ft. machine shop to be erected at 79 Francis Ave. Total cost, $15,000.

Conn., Parkville—The Jewel Belting Co., 55 Trumbull St., Hartford, plans to install a 500 hp. power plant in its proposed 1- and 2-story, 150 x 400 ft. belting factory. H. A. Wolcott, Elmwood, Arch.

Conn., Wallingford—R. Wallace & Sons is in the market for motors, shafting, etc. in connection with the proposed 3-story factory.

N. Y., Geneva—City had plans prepared by W. G. Frazer, Engr., 102 Clinton St., Buffalo, for the construction of a heating plant for the city hall and fire house.

N. Y., Maybrook Junction—The New York, New Haven and Hartford R. R., New Haven, Conn., is in the market for power piping, pumps, blowers, etc., in connection with the proposed 1-story, roundhouse to be erected here.

N. Y., New York—The Board of Education will soon award the contract for the installation of a heating system in the proposed 5-story, 92 x 194 ft. school on Crotona Ave. and East 180th St. C. B. Snyder, Municipal Bldg., Arch.

N. J., Bayonne—Y. M. C. A. plans to install a low pressure steam heating system in the proposed 3-story, 91 x 190 ft. building.

N. J., Boonton—City will receive bids until Aug. 14 for water-work improvements. Plan includes installation of one 2 in. and one 4 in. electrically driven, direct connected centrifugal pump, etc.

N. J., Newark—The Atlas Refining Co., Lockwood St., is in the market for 5 hp. motors. Gray & Ring, Arch.

Penn., Pennsburg—The Blackwater Stove Works plans to build a power plant on a newly acquired site here.

Penn., Philadelphia—The Bureau of Yards and Docks, Navy Dept., Wash., D. C., plans to install boilers and super-heaters here. Estimated cost, $206,000.

Penn., Philadelphia—The Bureau of Yards and Docks, Navy Dept., Wash., D. C., will receive bids until Aug. 19, for the erection of a battery storage building. Estimated cost, $125,000.

Penn., Philadelphia—The Dematological Research Co., 18th and Naudain St., is in the market for a high pressure boiler system. J. E. Fieldstein, Penfield Bldg., Engr.

Penn., Philadelphia—The Wheeler Manufacturing Co., 18th and Sedgley Ave., is in the market for a 300 hp. engine for its engine house.

Penn., South Bethlehem—The Philadelphia and Reading R. R. will soon award the contract for the erection of a 1-story, 110 x 200 ft. engine house on Sancon Creek. High pressure boilers will be installed.

Penn., South Bethlehem—The Philadelphia and Reading R. R., Philadelphia, will soon award the contract for the erection of a 1-story, 36 x 77 ft., concrete, brick and steel power house on Sancon Creek. High pressure boilers will be installed.

D. C., Wash.—The Bureau of Yards and Docks, Navy Dept., Wash., D. C., plans to build a boiler plant at Hampton Roads, Va. Estimated cost, $100,000.

D. C., Wash.—The Bureau of Supplies and Accounts, Navy Dept., will receive bids until Aug. 26, for equipment as follows:

Schedule No. 5384½, generating sets, delivery, Brooklyn, N. Y.

Schedule No. 5394½, motor, delivery, Philadelphia, Penn.

Va., Norfolk—The Bureau of Yards and Docks, Navy Dept., Wash., D. C., plans to install boilers and super-heaters here. Estimated cost, $96,000.

Va., Richmond—C. M. Robinson, Arch., Times-Dispatch Bldg., is receiving bids for the erection of an addition to the heating plant of the Times-Dispatch Co., Times-Dispatch Bldg.

La., Baton Rouge—Y. M. C. A. plans to install a low pressure steam heating system in its proposed 3-story, 75 x 112 ft. building. Shattuck & Hussey, 19 South La Salle St., Chicago, Arch.

Ky., Paris—The Paris Water Co. is in the market for 1 centrifugal pump, 150,000 gal. capacity, direct connected to 20 hp. 3-phase, 60 cycle, 2300 volt motor. N. Mitchell, Supt.

Ohio, Canton—The Timken Roller Bearing Co. has increased its capital stock from $200,000 to $10,000,000; the proceeds will be used to build a power plant and various other units.

Ind., Indianapolis—The American Hominy Co., Fletcher Savings and Trust Bldg., will install a steam heating system in its proposed 6-story warehouse.

Ind., Indianapolis—The Prestolite Co., 510 North Capital Ave., will install a steam heating system in the proposed 1-story, 100 x 400 ft. factory to be erected at Speedway City. Total cost, $100,000.

Mich., Detroit—R. E. Olds, 200 Capitol Natl. Bank Bldg., Lansing, is in the market for tubular boilers, automatic stokers, etc., in connection with the proposed 9-story, 100 x 200 ft. mercantile building to be erected on Campius Martius St. Baxter, O'Dell and Halpin, 1024 Hammond Bldg., Arch.

Ill., Chicago—Armour & Co., Union Stock Yards, plans to install a refrigeration plant in connection with the proposed 2-story, 90 x 122 ft., brick and concrete market house at 2617 West Madison St.

Ill., Chicago—The Central Trading Co., 135 South La Salle St., plans to install a low pressure steam heating system in its 1- and 3-story, brick warehouse on 21st and Loomis St. Total cost, $50,000. Lewis & Dougherty, 35 North Dearborn St., Arch.

Ill., Great Lakes—The Bureau of Yards and Docks, Navy Dept., Wash., D. C., will soon award the contract for the installation of a steam heating system in the maintenance building here. Estimated cost, $30,000.

Wis., Milwaukee—Swift & Co., 2nd a..d Fowler St., plans to build an addition to its boiler house here.

Minn., St. Peter—The State Board of Control, St. Paul, plans to install a low pressure steam heating system in the proposed 3-story, 40 x 160 ft., men's dormitory at the Hospital for Insane here. Total cost, $50,000. C. H. Johnston, Capital Bank Bldg., St. Paul, Arch.

Kan., Baxter Springs—The Board of Education is in the market for a heating plant to be installed in the proposed 2-story, 83 x 173 ft. high school. B. C. Overton, Arch.

Kan., El Dorado—The Board of Education, Dist. No. 37, Butler Co., plans to install a steam heating and mechanical ventilation system in the proposed 2-story, 80 x 90 ft. school. Total cost, $50,000. W. H. Simon, El Dorado, Arch.

S. D., Pierre—City will receive bids until Aug. 26 for the erection of a power plant here.

Mo., Joplin—Y. M. C. A. plans to install a steam heating system and boilers in the proposed new building on 5th and Wall St. J. S. Graville, Secy. Smith, Rea and Lovett, 601 Finance Bldg., Kansas City, Engr.

Mo., Kansas City—City is in the market for steam turbines, reduction gar centrifugal pump, 20,000,000 gal. capacity, 370 ft. head, 165 lb. steam pressure. J. R. Samuels, Purch. Agt.

Mo., St. Louis—The G. B. Allen Estate, La Salle Bldg., plans to install power equipment in its proposed 4-story loft and factory building on Washington St. Total cost, $18,000. Pelligreen Co., Grand and Park Ave., Engr.

Mo., Warrensburg—City is having preliminary plans prepared by Archer & Stevens, Arch., 609 New England Bldg., Kansas City, for the construction of an electric lighting plant.

Ark., Ashdown—The Commonwealth Public Service plans to install an engine and dynamo in its electric lighting plant.

Tex., Gainsville—The Whaley Mill and Elevator Co., 110-120 North Denison St., plans to install a steam heating system in the proposed 7-story, 34 x 100 ft. flour mill.

Okla., Ardmore—E. S. Boze, Arch., will receive bids until Sept. 15, for the erection of a 3-story hotel for J. C. Mulkey. Boilers and other equipment will be installed. Total cost, $50,000.

Okla., Ponca City—City voted $75,000 bonds to improve the lighting and waterworks system. Plans include the installation of a new generator and extensions to mains. Burns & McDonnell, Interstate Bldg., Kansas City, Mo., Engr.

Okla., Quapaw—The Alamo Lead and Zinc Co. will install an engine, boilers, air compressors, belts, etc., in its proposed concentration plant to be erected near here. Estimated cost, $65,000. J. T. Burgher, Dallas, Tex., Supt.

Wash., Vancouver—The G. M. Standifer Shipbuilding Co. plans to install a steam heating system in its proposed 3-story, 150 x 300 ft. employees' hotel. Total cost, $500,000.

Calif., San Francisco—A. T. McElvaine, c/o G. F. Stoner, 948 Market St., is in the market for a small electric hoist, small compressor and a power drill.

Calif., Woodland—The Pacific Gas and Electric Co. plans to build a sub-station at Knights Landing, Yolo Co. Estimated cost, $250,000. The new plant will be used to connect a line from here to Colusa.

CONTRACTS AWARDED

Mass., Boston—The Bureau of Yards and Docks, Navy Dept., Wash., D. C., has awarded the contract for the installation of air compressors to the Ingersoll-Rand Co., 11 B'way, New York City, $75,575 (250 days).

Mass., Fairhaven—The New Bedford Gas and Edison Light Co., New Bedford, will build a 1-story, 20 x 25 ft. transformer house by day labor.

Mass., Pittsfield—The Taconic Mills, c/o J. and E. H. Wilson, has awarded the contract for the erection of a 1-story, 42 x 42 ft. turbine house, to D. H. Pike, 28 Rennie Ave.

Conn., New London—The Bureau of Yards and Docks, Navy Dept., Wash., D. C., has awarded the contract for the installation of electrical equipment in the power plant here, to the Mace Eng. Corp., 38 Chadron St., Boston, Mass. Estimated cost, $22,500. Noted July 9.

N. Y., Buffalo—The Pierce Arrow Motor Car Co., 1695 Elmwood Ave., has awarded the contract for the erection of a 5-story, 40 x 44 ft., power house to the Stone and Webster Corp., 147 Milk St., Boston, Mass. About $250,000; cost plus percentage.

Penn., Philadelphia—The Bureau of Yards and Docks, Navy Dept., Wash., D. C., has awarded the contract for the installation of air compressors, to the Ingersoll-Rand Co., 11 Bway., New York City, $75,475 (250 days).

Md., Baltimore—The Baltimore & Ohio R. R. has awarded the contract for the erection of an addition to its coal thawing plant at Curtis Bay near here, to the Surety Eng. Co., 30 Church St., New York City. Estimated cost, $50,000.

D. C., Wash.—The Bureau of Yards and Docks, Navy Dept., Wash., D. C., has awarded the contract for the installation of surface condensers and auxiliary pumps at Navy Yards, Philadelphia, Penn., and Wash., D. C., to the Wheeler Condenser and Eng. Co., 520 Woodward Bldg., $72,885 (120 days).

Ill., Great Lakes—The Bureau of Yards and Docks, Navy Dept., Wash., D. C., received bids Aug. 5, for the erection of a mess hall and power house at Camp Paul Jones (work complete) from H. F. Friestedt, 327 South La Salle St., Chicago, $340,054 (50 days); J. Griffith and Son, 162 West Adam St., Chicago, $459,000 (50 days); Warner Constr. Co., 189 West Madison St., Chicago, $378,671 (50 days). Noted July 30.

Minn., Chakopee—The State Board of Control, St. Paul, has awarded the contract for the installation of a heating and plumbing system in the Women's Reformatory here to M. K. O'Neil, 97 East 8th St., St. Paul. Estimated cost, $18,000.

Minn., White Bear—The Board of Education has awarded the contract for the installation of a heating and plumbing system in the proposed 3-story, 66 x 96 ft. school on Bald Eagle Ave., to the Healey Plumbing and Heating Co., 278 West 3rd St., St. Paul. Estimated cost, $14,300.

B. C., Vancouver—The Dominion Canneries, Ltd., has awarded the contract for the erection of a concrete boiler house to J. J. Newitt, 954 17th Ave., W.

THE COAL MARKET

Boston—Current quotations per gross ton f.o.b. mines are as follows:

ANTHRACITE

	Circular Current
Buckwheat	$3.40
Rice	2.90
Boiler	2.65
Barley	2.40

All-rail rate to Boston is $2.86.

BITUMINOUS

Bituminous, $8 to $8.75.

Pocahontas and New River, f.o.b. Boston, $8.35 to $8.90.

New York—Current quotations per gross ton f.o.b. Tidewater at the lower ports* are as follows:

	Circular	Individual
Pea	$5.20	$5.95
Buckwheat	5.15	5.90
Rice	4.65	5.10
Barley	4.15	4.30
Boiler	4.60	....
Broken	6.75	7.50
Egg	6.35	7.10
Stove	6.60	7.35
Chestnut	6.70	7.45

Quotations for domestic coals at the upper ports are 5c. higher on account of the differenec in freight rates. Prices for buckwheat, rice, barley and boiler are not fixed by the Government.

BITUMINOUS

Current quotations, gross tons, based on Government prices at the mines, net ton; f.o.b. Tidewater, at the lower ports, are as follows:

	Mine Gross	F.O.B. N.Y. Gross
Central Pennsylvania (Mine run, Prepared or Slack)	$3.30	$5.45
Upper Potomac, Cumberland & Piedmont Fields:		
Run of Mine	3.08	5.23
Prepared	3.36	5.51
Slack	2.80	4.95

Quotations at the upper ports are 5c. higher on account of the difference in freight rates.

The foregoing prices ar exclusive of the 3 per cent. war freight tax on both anthracite and bituminous.

*The lower ports are: Elizabethport, Port Johnson, Port Reading, Perth Amboy and South Amboy. The upper ports are: Port Liberty, Hoboken, Weehawken, Edgewater or Cliffside and Guttenberg. St. George is in between and sometimes a special boat rate is made. Some bituminous is shipped from Port Liberty. The ratte to the upper ports is 5c. higher than to the lower ports.

Philadelphia—Prices per gross ton f.o.b. cars at mines for line shipment and f.o.b. Port Richmond for tide shipment are as follows:

	Line		Tide	
	Current	One Yr. Ago	Current	One Yr. Ago
Pea	$3.45	$3.10	$4.60	$4.00
Barley	2.40	1.90	3.30	2.15
Buckwheat	3.40	2.90	4.45	3.80
Rice	2.90	2.40	3.80	3.40
Boiler	2.70	2.20	3.70	3.30

Chicago—Steam coal prices f.o.b. mines:

Illinois Coals	Southern Illinois	Northern Illinois
Prepared sizes	$2.55—2.70	$3.25—3.40
Mine-run	2.35—2.50	3.00—3.15
Screenings	2.05—2.20	2.75—2.90

St. Louis—Prices per net ton f.o.b. mines are as follows:

	Williamson and Franklin Counties	Mt. Olive & Staunton	Standard
6-in. lump	$2.55-2.70	$2.55-2.70	$2.40@2.70
2-in. lump	2.55-2.70	2.55-2.70	2.40@2.70
Steam egg	....	....	2.40@2.70
Mine-run	2.35-2.50	2.35-2.50	1.85@2.00
No. 1 nut	2.35-2.50	2.55-2.70	....
2-in. screen	2.05-2.20	2.05-2.20	....
No. 5 washed	2.05-2.20	2.05-2.20	1.25@1.50

Williamson-Franklin rate to St. Louis is $1.10, other rates, $0.95.

Birmingham—Current prices per net ton f.o.b. mines are as follows:

	Mine-Run	Prepared Sizes	Slack or Screenings
Big Seam	$2.50	$2.80	$2.20
Cahaba, Black Creek, Brookwood, Blue Creek	3.20	3.45	2.80
Pratt, Jaeger, Jefferson Nickel Plate	2.70	3.00	2.40
Corona	2.75	3.10	2.40

The above are Government prices per net ton of 2000 lb. mines and include the 45c. per ton allowed by the wage agreement, less 10c. reduction which was effective May 25, as a result of the agreement with the railroad administration for furnishing fuel coal.